The Blast Furnace and Steel Plant

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# Substituting Machines For Men

THREE important phases of the immigration problem will be discussed at a special group session held in connection with the forthcoming annual meeting of the Chamber of Commerce of the United States at Cleveland, May 6 to 8.

This group session, which is being arranged under the auspices of the Chamber's Civic Development Department, will deal with these subjects:

Essentials of American Citizenship.

The Immigrant's Part Today in Industrial and Agricultural Development.

How Far Can Those Now Here, Native Born and Foreign Born, Plus Labor Saving Machinery, Take the Place of the Immigrant in the Future?

Discussion of the last question is expected to bring out much important data which will be useful in the formation of a future immigration policy. In a statement discussing this phase of the Civic Development group, John Ihlder, manager of the department, said:

"The United States has achieved its industrial leadership largely through its genius in devising machinery which will not only take the place of human muscle, but will produce many times as much. From the old time cobbler sitting cross-legged on his bench to the shoe factory of today is a long stride, but one that has been matched in many other lines. Flour is now untouched by human hands from the time it enters the bakery until the loaf of bread is placed on the consumer's table; iron from the time it is smelted until ready for shipment is processed by machinery; ditches for our water mains and sewers are dug, not with pick and shovel, but by machines. Our products are multiplied, the number of men required for drudgery decreased. But at the same time the demand for men trained and with alert minds, quick-thinking and resourceful, is increasing.

"Can this process of substituting machines for men be speeded up so that the demand for unskilled labor will decrease and the product per man plus machine increase enough to meet our needs?"

# Metalloids in Basic Pig Iron in Basic Openhearth Practice*

## This is a Continuation of a Most Interesting Phase of Open Hearth Study

By C. L. KINNEY, JR.†

THE determination of the quantities of earthy bases to be charged for any given amounts of silica and phosphorus may most conveniently be ascertained by taking an average composition of those slags that, under given conditions, have yielded economical operation, and empirically separating it into a silicate slag (which is assumed to hold the phosphate slag in solution) and a phosphate slag, in which the phosphorus is assumed to be combined with calcium oxide in the form of $Ca_4P_2O_9$. When this has been done, the analysis of the silicate slag is calculated, and from this the relation of the silica to the lime plus magnesia and to the weight of the silicate slag is determined. The total weight of slag, of course, is the weight of the silicate slag plus the phosphate slag, the last named being the weight of the phosphorus oxidized multiplied by 5.9. In our operation, the average composition of generally satisfactory slags shows a silicate portion which analyzes as follows: $SiO_2$, 19 per cent; $FeO + MnO$, 27 per cent; $Al_2O_3 + TiO_2 + S$, 2 per cent or a total of 48 per cent. Therefore, the $CaO + MgO$ necessary to equal 100 per cent is, by difference, 52 per cent, and the $CaO + MgO$ required per unit of $SiO_2$ is the ratio of 52 to 19 or 2.74; and the weight of silicate slag produced per unit of silica is the ratio of 100 to 19 or 5.26. These ratios are used in all the theoretical heats shown, except in the excessive limestone charge, where they become silicate slag to silica 7.1, and $MgO + CaO$ to $SiO_2$, 4.01. In all cases the ratio of phosphorus to calcium oxide is 1 to 3.61, which corresponds to the composition of the tetrabasic phosphate. Tables 13 and 14 give the ratios and the analyses of the theoretical slags used in the construction of the chemical and thermal balances and cost sheet.

### THERMAL BALANCE SHEET

#### Heat Absorbed

THERMOCHEMICAL CHANGES

Reduction of oxides of Iron:

Heat of formation of $Fe_2O_3 = 3240$

Heat of formation of $FeO = 2430$

Input:

$Fe_2O_3 = 6661$

$FeO = 108$

Heat of formation:

$Fe_2O_3 = 6661 \times 3240 = 21.58 \times 10^6$ B.t.u.

$FeO = 108 \times 2430 = 0.26 \times 10^6$ B.t.u.

Total = $21.84 \times 10^6$ B.t.u.

Output:

Tapping slag = $FeO = 3268 \times 2430 = 7.94 \times 10^6$

Moisture in ore:

Total weight of ore = 9170 lb.

Per cent moisture = 8

Total water = 734

Total heat to make steam at 212°

$734 \times 1092 = 0.80 \times 10^6$ B.t.u.

Specific heat of steam $0.42 + 0.00013\ (2800 + 212) = 0.81$

Heat in superheat $734\ (2800 - 212)\ 0.81 = 1.54 \times 10^6$ B.t.u.

Total = $2.34 \times 10^6$ B.t.u.

Decomposition of limestone:

Heat of formation $CaCO_3$ per lb. = 772 B.t.u.

Total limestone = 11,675 lb.

Total heat required = $11{,}675 \times 772 = 9.01 \times 10^6$ B.t.u.

Moisture 1.5 per cent = 175 lb.

Total heat to make steam = $175 \times 1092 = 0.19 \times 10^6$

Heat in superheat = $175 \times 2096 = 0.37 \times 10^6$

Total = $0.56 \times 10^6$

Decomposition of improperly burned dolomite:

Total weight of dolomite = 2500 lb.

Volatile = 15.54 per cent = 389 lb.

Assumed 98 per cent = 381 exists as $CO_2$

To drive off $CO_2$ = 1756 B.t.u. per lb.

Total heat to drive off $CO_2 = 381 \times 1756 = 0.67 \times 10^6$ B.t.u.

THERMOPHYSICAL CHANGE

Hot metal = 65,000 lb. Temperature = 2474° F.

Tapping temperature = 3080° F. includes emissivity factor.

Temperature rise (3080 — 2474) = 606° F.

Specific heat = 0.2

Heat absorbed = $65{,}000 \times 606 \times 0.2 = 7.88 \times 10^6$ B.t.u.

Scrap = 35,000 lb. Temperature = 62° F.

Melting temperature scrap = 2795° F.

Heat required to bring to melting temperature = $35{,}000 \times 2733 \times 0.16 = 15.30 \times 10^6$

Latent heat of fusion = 72 B.t.u.

Total heat of fusion = $35{,}000 \times 72 = 2.52 \times 10^6$

Heat to raise to temperature of bath:

$(3080 - 2795)\ 35{,}000 \times 0.2 = 2.00 \times 10^6$

Total heat = $19.82 \times 10^6$

Total heat in molten slag:

Heat in tapping slag = $15{,}465 \times 1066 = 16.49 \times 10^6$ B.t.u.

Total heat absorbed = $70.67 \times 10^6$ B.t.u.

#### Heat Generated

Oxidation of carbon, weight = 2669 lb.

Heat of formation of CO from C per lb. = 4374 B.t.u.

Heat generated = $4374 \times 2669 = 11.67 \times 10^6$

Oxidation of manganese, weight = 645 lb.

Heat of formation of $MnO$ = 2984 B.t.u.

Heat generated = $2984 \times 645 = 1.92 \times 10^6$

Oxidation of silicon, weight = 488 lb.

Heat of formation of $SiO_2$ = 11,693 B.t.u.

Heat generated = $11{,}693 \times 488 = 5.71 \times 10^6$

Oxidation of phosphorus, weight = 129 lb.

Heat of formation of $P_2O_5$ = 10,825 B.t.u.

Heat generated = $10{,}825 \times 129 = 1.40 \times 10^6$

Heat of formation of slag, weight = 15,465 lb.

Heat of formation of slag = 74 B.t.u.

Heat generated = $15{,}465 \times 74 = 1.14 \times 10^6$

Total heat generated = $21.84 \times 10^6$ B.t.u.

#### Authorities for Constants Used

THERMOCHEMICAL CHANGES

Iron oxide reduction—Richards

Decomposition of limestone—U. S. Bureau of Standards

Oxidation of C, Mn, Si, P—Richards, LeChatelier, Berthelot, Thomson

Formation of slag, calculated using Richards' values

THERMOPHYSICAL CHANGE

Specific heat, pig iron—0.1665—Oberhoffer

Specific heat, soft steel—0.16—Meuther

Latent heat of fusion, pig iron—Hutter

Latent heat of fusion, steel—average value—Jetner, Richards, Brisker

Heat in molten slag—Springorum

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## TABLE 10.—*Excess Limestone Heat*

### CHEMICAL BALANCE SHEET

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Material** | Weight in Pounds | Per Cent. C | Pounds C | Pounds CO | Per Cent. Si | Pounds Si | Per Cent. $SiO_2$ | Pounds $SiO_2$ | Per Cent. P | Pounds P | Per Cent. $P_2O_5$ | Pounds $P_2O_5$ | Per Cent. Mn | Per Cent. MnO | Pounds Mn | Per Cent. S |
| **Basic hot metal** | 65,000 | 4.30 | 2,795 | | 0.75 | 488 | | 1,039 | 0.20 | 130 | | | 1.00 | | 650 | 0.04 |
| **Structural steel scrap** | 35,000 | 0.20 | 70 | | | | | | 0.01 | 4 | | | 0.40 | | 140 | 0.04 |
| **Chapin ore (natural)** | 9,170 | | | | | | 9.29 | 852 | 0.05 | 5 | | | 0.13 | | 12 | Tr. |
| **Michigan limestone** | 11,675 | | | | | | 0.34 | 40 | 0.006 | | | | | | | 0.042 |
| **Calcined dolomite** | 2,500 | | | | | | 1.32 | 33 | 0.004 | | | | | | | 0.126 |
| **Fluorspar** | 600 | | | | | | 1.12 | 7 | 0.004 | | | | | | | |
| **$SiO_2$ from furnace structure** | | | | | | | | 100 | | | | | | | | |
| **Total entering furnace** | | | 2,865 | | | 488 | | | | 139 | | | | | 802 | |
| **Total steel in bath** | 98,211 | 0.20 | 196 | | | | | | 0.01 | 10 | | | 0.16 | | 157 | 0.035 |
| **Tapping slag, 100.01 per cent** | 15,465 | | | | | | 13.39 | 2,071 | | 129 | 1.91 | 295 | | 4.54 | 544 | 0.25 |
| **Total output** | | | | | | | | | | | | | | | 701 | |
| **Unaccounted for** | | | | | | | | | | | | | | | −101 | |
| **Metalloids oxidized** | | | 2,669 | | | 488 | | | | 129 | | | | | 645 | |

| | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Material | Pounds S | Per Cent. CaO | Pounds CaO | Per Cent. MgO | Pounds MgO | Per Cent. Fe | Pounds Fe | Per Cent. FeO | Pounds FeO | Per Cent. $Fe_2O_3$ | Pounds $Fe_2O_3$ | Per Cent. $Al_2O_3$ | Pounds $Al_2O_3$ | Per Cent. $CaF_2$ | Per Cent. Volume | Per Cent Moisture |
| **Basic hot metal** | 26 | | | | | | 60,898 | | | | | | | | | |
| **Structural steel scrap** | 14 | | | | | | 34,772 | | | | | | | | | |
| **Ore (natural)** | | 1.60 | 147 | 2.64 | 242 | 51.76 | 4,746 | 1.18 | 108 | 72.64 | 6,661 | 1.10 | 101 | | 3.15 | 8.00 |
| **Michigan limestone** | 4 | 54.60 | 6,375 | 0.88 | 103 | 0.20 | 23 | | | | | 0.30 | 35 | | | 1.50 |
| **Calcined dolomite** | 5 | 48.58 | 1,215 | 32.58 | 815 | 0.38 | 10 | | | | | 1.49 | 37 | | 15.54 | |
| **Fluorspar** | | 2.50 | 15 | 0.38 | 2 | | | | | | | 1.15 | 7 | 9,253 | | |
| **$SiO_2$ from furnace structure** | | | | | | | | | | | | | | | | |
| **Total entering furnace** | 50 | | 7,752 | | 1,162 | | 100,449 | | | | | | 180 | | | |
| **Total steel in bath** | 34 | | | | | | 97,813 | | | | | | | | | |
| **Tapping slag, 100.01 per cent** | 39 | 50.13 | 7,752 | 7.51 | 1,162 | | 2,536 | 21.12 | 3,268 | | | 1.16 | | | | |
| **Total output** | 73 | | | | | | 100,349 | | | | | | | | | |
| **Unaccounted for** | +23 | | | | | | −100 | | | | | | | | | |
| **Metalloids oxidized** | | | | | | | 100 | | | | | | | | | |

### Thermal Balance Sheet

#### HEAT ABSORBED

Red. of oxides of Fe = 13.90
Absorp. moist. of ore = 2.34
Decomp. of limestone = 9.01
Absorp. moist. of limestone = 0.56
Decomp. of dolomite = 0.67
Heat in moletn slag = 16.49
Heat added to mixer metal = 7.88
Heat added to scrap = 19.82

#### HEAT GENERATED

Oxidation of C = $11.67 \times 10^6$
Oxidation of Mn = $1.92 \times 10^6$
Oxidation of Si = $5.71 \times 10^6$
Oxidation of P = $1.40 \times 10^6$
Heat form. slag = $1.14 \times 10^6$
Balance heat to be supplied by combustion of gases in furnace $48.83 \times 10^6$
Total B.t.u. = $70.67 \times 10^6$

#### THERMAL EFFICIENCY OF BATH

Thermal efficiency of furnace = 17.3 per cent
B.t.u. in gas per pound of coal = 10,625

*Total B.t.u. to be supplied in producer gas $= \dfrac{48.83 \times 10^6}{0.173} =$ $282.25 \times 10^6$

Total coal burned = 26,564 lb.

### THERMAL BALANCE SHEET

#### Heat Absorbed

#### THERMOCHEMICAL CHANGES

Reduction of oxides of iron:
Heat of formation of $Fe_2O_3$ = 3240
Heat of formation of FeO = 2430
Input:
$Fe_2O_3$ = 9419
FeO = 153
Heat of formation:
$Fe_2O_3 = 9419 \times 3240 = 30.52 \times 10^6$
$FeO = 153 \times 2430 = 0.37 \times 10_3$
Total = $30.89 \times 10^6$

Output:
Tapping slag = FeO = $4675 \times 2430 = 11.36 \times 10^6$
Moisture in ore:
Total weight of ore = 12,967 lb.
Per cent moisture = 8.00
Total water = 1037
Total heat to make steam at 212° = $1037 \times 1092 = 1.13 \times 10^6$
Specific heat of steam = $0.42 + 0.00013 \times (2800 + 212) = 0.81$
Heat in superheat = $1037 \times (2800 - 212)\ 0.81 = 2.17 \times 10^6$
Total = $3.30 \times 10^6$
Decomposition of limestone:
Heat of formation $CaCO_3$ per lb = 772 B.t.u.
Total limestone = 15,081
Total heat required = $15{,}081 \times 772 = 11.64 \times 10^6$
Moisture 1.5 per cent = 226
Total heat to make steam = $226 \times 1092 = 0.25 \times 10^6$
Heat in superheat = $2096 + 226 = 0.47 \times 10^6$
Total = $0.72 \times 10^6$
Decomposition of improperly burned dolomite:
Total weight of dolomite = 2500 lb.
Volatile—15.54 per cent = 389 lb.
Assumed 98 per cent = 381 exists as $CO_2$
To drive off $CO_2$ = 1756 B.t.u. per lb.
Total heat to drive off $CO_2 = 1756 \times 381 = 0.67 \times 10^6$

#### THERMOPHYSICAL CHANGE

Hot metal = 65,000 lb. Temperature = 2474° F.
Tapping temperature = 3080° F. includes emissivity factor
Temperature rise (3080 — 2474) = 606° F.
Specific heat = 0.2
Heat absorbed = $65{,}000 \times 606 \times 0.2 = 7.88 \times 10^6$
Scrap = 35,000 lb. Temperature = 62° F.
Melting temperature scrap = 2795° F.
Heat required to bring to melting temperature = $35{,}000 \times 2733 \times 0.16 = 15.30 \times 10^6$
Latent heat of fusion = 72 B.t.u.
Total heat of fusion = $35{,}000 \times 72 = 2.52 \times 10^6$
Heat to raise to temperature of bath = $(3080 - 2795)\ 35{,}000 \times 0.2 = 2.00 \times 10^6$
Total heat = $19.82 \times 10^6$
Total heat in molten slag:
Heat in tapping slag = $20{,}897 \times 1066 = 22.25$ B.t.u.
Total heat absorbed = $8584 \times 10^6$ B.t.u.

### Heat Generated

Oxidation of carbon, weight = 2669 lb.
  Heat of formation of CO from C per lb. = 4374 B.t.u.
    Heat generated = 4374 × 2669 = 11.67 × $10^6$
Oxidation of manganese, weight = 689 lb.
  Heat of formation of MnO = 2984 B.t.u.
    Heat generated = 2984 × 689 = 2.06 × $10^6$
Oxidation of silicon, weight = 1138 lb.
  Heat of formation of $SiO_2$ = 11,693 B.t.u.
    Heat generated = 11,693 × 1138 = 13.31 × $10^6$
Oxidation of phosphorus, weight = 130 lb.
  Heat of formation of $P_2O_5$ = 10,825 B.t.u.
    Heat generated = 10,825 × 130 = 1.41 × $10^6$
Heat of formation of slag, weight = 20,897 lb.
  Heat of formation of slag = 84 B.t.u.
    Heat generated = 20,897 × 84 = 1.75 × $10^6$
      Total heat generated = 30.20 × $10^6$ B.t.u.

### Authorities for Constants Used

#### THERMOCHEMICAL CHANGES

Iron oxide reduction—Richards
Decomposition of limestone—U. S. Bur. of Standards
Oxidation of C, Mn, Si, P—Richards, LeChatelier, Berthelot, Thomson
Formation of slag, calculated using Richards' volumes

#### THERMOPHYSICAL CHANGE

Specific heat, pig iron—0.1665—Oberhoffer
Specific heat, soft steel—0.16—Meuther
Latent heat of fusion, pig iron—Hutter
Latent heat of fusion, steel—average value—Jetner, Richards, Brisker
  Heat in molten slag—Springorum

### Thermal Balance Sheet

#### HEAT ABSORBED

Red. of oxides of Fe = 19.53
Absorp. moist. of ore = 3.30
Decomp. of limestone = 11.64
Absorp. moist. of limestone = 0.72
Decomp. of dolomite = 0.67
Heat in molten slag = 22.28
Heat added to mixer metal = 7.88
Heat added to scrap = 19.82

#### HEAT GENERATED

Oxidation of C = 11.67 × $10^6$
Oxidation of Mn = 2.06
Oxidation of Si = 13.31
Oxidation of P = 1.41
Heat form. slag = 1.75
Balance heat to be supplied by combustion of gases in furnace = 55.64 × $10^6$
  Total B.t.u. = 85.84 × $10^6$

#### THERMAL EFFICIENCY OF BATH

Thermal efficiency of furnace = 17.3 per cent.
B.t.u. in gas per pound of coal = 10,625

$$\text{Total B.t.u. to be supplied in producer gas} = \frac{55.64 \times 10^6}{0.173} = 321.62 \times 10^6 \text{ B.t.u.}$$

  Total coal burned = 30,270 lb.

### THERMAL BALANCE SHEET

#### Heat Absorbed

##### THERMOCHEMICAL CHANGES

Reduction of oxides of iron:
  Heat of formation of $Fe_2O_3$ = 3240
  Heat of formation of FeO = 2430
Input:
  $Fe_2O_3$ = 8034
  FeO = 131
  Heat of formation:
    $Fe_2O_3$ = 3240 × 8034 = 26.03 × $10^6$
    FeO = 131 × 2430 0.32 × $10^6$
      Total = 26.35 × $10^6$
Output:
  Tapping slag—FeO = 2474 × 2430 = 6.01 × $10^6$
Moisture in ore:
  Total weight of ore = 11,060 lb.
  Per cent moisture = 8
  Total water = 885
  Total heat to make steam at 212° = 885 × 1092 = 0.97 × $10^6$
  Specific heat of steam = 0.42 + 0.00013 (2800 — 212) = 0.81

### TABLE 11.—*High-silicon Iron Furnace Charge*

#### CHEMICAL BALANCE SHEET

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Material | Weight in Pounds | Per Cent. C | Pounds C | Pounds CO | Per Cent. Si | Pounds Si | Per Cent. $SiO_2$ | Pounds $SiO_2$ | Per Cent. P | Pounds P | Per Cent. $P_2O_5$ | Pounds $P_2O_5$ | Per Cent. Mn | Per Cent. MnO | Pounds Mn | Per Cent. S |
| Basic hot metal | 65,000 | 4.30 | 2,795 | | 1.75 | 1,138 | | 2,435 | 0.20 | 130 | | | 1.00 | | 650 | 0.04 |
| Structural steel scrap | 35,000 | 0.20 | 70 | | | | | | 0.01 | 4 | | | 0.40 | | 140 | 0.04 |
| Chapin ore (natural) | 12,967 | | | | | | 9.29 | 1,205 | 0.05 | 6 | | | 0.13 | | 17 | |
| Michigan limestone | 15,081 | | | | | | 0.34 | 51 | 0.006 | | | | | | | 0.042 |
| Calcined dolomite | 2,500 | | | | | | 1.32 | 33 | 0.004 | | | | | | | 0.126 |
| Fluorspar | 300 | | | | | | 1.12 | 3 | 0.004 | | | | | | | |
| $SiO_2$ from furnace structure | | | | | | | | 100 | | | | | | | | |
| Total entering furnace | | | 2,865 | | | 1,138 | | 3,827 | | 140 | | | | | 807 | |
| Total steel in bath | 98,431 | 0.20 | 196 | | | | | | 0.01 | 10 | | | 0.12 | | 118 | 0.04 |
| Tapping slag, 99.50 per cent | 20,897 | | | | | | 18.31 | 3,827 | | 130 | 1.42 | 297 | | 3.64 | 589 | 0.25 |
| Total output | | | | | | | | 3,827 | | 140 | | | | | 707 | |
| Unaccounted for | | | | | | | | | | | | | | | 100 | |
| Metalloids oxidized | | | 2,669 | | | 1,138 | | | | 130 | | | | | 689 | |

| | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Material | Pounds S | Per Cent. CaO | Pounds CaO | Per Cent. MgO | Pounds MgO | Per Cent. Fe | Pounds Fe | Per Cent. FeO | Pounds FeO | Per Cent. $Fe_2O_3$ | Pounds $Fe_2O_3$ | Per Cent. $Al_2O_3$ | Pounds $Al_2O_3$ | Per Cent. $CaF_2$ | Per Cent. Volume | Per Cent. Moisture |
| Basic hot metal | 26 | | | | | | 60,261 | | | | | | | | | |
| Structural steel scrap | 14 | | | | | | 34,772 | | | | | | | | | |
| Chapin ore (natural) | | 1.60 | 207 | 2.64 | 342 | 51.76 | 6,718 | 1.18 | 153 | 72.64 | 9,419 | 1.10 | 143 | | 3.15 | 8.00 |
| Michigan limestone | 6 | 54.60 | 8,234 | 0.88 | 133 | 0.20 | 30 | | | | | 0.30 | 45 | | | 1.50 |
| Calcined dolomite | 3 | 48.58 | 1,215 | 32.58 | 815 | 0.38 | 10 | | | | | 1.49 | 37 | | 15.54 | |
| Fluorspar | | 2.50 | 8 | 0.38 | 1 | | | | | | | 1.15 | 3 | 92.53 | | |
| $SiO_2$ from furnace structure | | | | | | | | | | | | | | | | |
| Total entering furnace | 49 | | 9,664 | | 1,291 | | 101,791 | | | | | | 228 | | | |
| Total steel in bath | 40 | | | | | 99 63 | 98,067 | | | | | | | | | |
| Tapping slag, 99.50 per cent | 52 | 46.24 | 9,664 | 6.18 | 1,291 | | 3,624 | 22.37 | 4,675 | | | | 109 | | | |
| Total output | 92 | | 9,664 | | 1,291 | | 101,691 | | | | | | | | | |
| Unaccounted for | +43 | | | | | | −100 | | | | | | | | | |
| Metalloids oxidized | | | | | | | 100 | | | | | | | | | |

## TABLE 12.—*High-phosphorus, Iron Furnace Charge*

### CHEMICAL BALANCE SHEET

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Material | Weight in Pounds | Per Cent. C | Pounds C | Pounds CO | Per Cent. Si | Pounds Si | Per Cent. $SiO_2$ | Pounds $SiO_2$ | Per Cent. P | Pounds P | Per Cent. $P_2O_5$ | Pounds $P_2O_5$ | Per Cent. Mn | Per Cent. MnO | Pounds Mn | Per Cent. S |
| Basic hot metal | 65,000 | 4.30 | 2,795 | | 0.75 | 488 | | 1,039 | 0.70 | 455 | | | 1.00 | | 650 | 0.01 |
| Structural steel scrap | 35,000 | 0.20 | 70 | | | | | | 0.01 | 4 | | | 0.40 | | 140 | 0.01 |
| Chapin ore (natural) | 11,060 | | | | | | 9.29 | 1,027 | 0.05 | 6 | | | 0.13 | | 14 | |
| Michigan limestone | 9,473 | | | | | | 0.34 | 32 | 0.006 | | | | | | | 0.042 |
| Calcined dolomite | 2,500 | | | | | | 1.32 | 33 | 0.004 | | | | | | | 0.126 |
| Fluorspar | 300 | | | | | | 1.12 | 3 | 0.004 | | | | | | | |
| $SiO_2$ from furnace structure | | | | | | | | 100 | | | | | | | | |
| Total entering furnace | | | 2,865 | | | 488 | | 2,234 | | | | | | | 804 | |
| Total steel in bath | 99,501 | 0.20 | 199 | | | | | | 0.03 | 30 | | | 0.16 | | 159 | 0.04 |
| Tapping slag, 99.71 per cent | 14,318 | | | | | | 15.60 | 2,234 | | 435 | 696 | 996 | | 4.87 | 541 | 0.25 |
| Total output | | | 199 | | | | | | | 465 | | | | | | |
| Unaccounted for | | | | | | | | | | | | | | | | |
| Metalloids oxidized | | | 2,667 | | | 488 | | | | 435 | | | | | | |

| | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Material | Pounds S | Per Cent. CaO | Pounds CaO | Per Cent. MgO | Pounds MgO | Per Cent. Fe | Pounds Fe | Per Cent. FeO | Pounds FeO | Per Cent. $Fe_2O_3$ | Pounds $Fe_2O_3$ | Per Cent. $Al_2O_3$ | Pounds $Al_2O_3$ | Per Cent. $CaF_2$ | Per Cent. Volume | Per Cent. Moisture |
| Basic hot metal | 26 | | | | | | 60,586 | | | | | | | | | |
| Structural steel scrap | 14 | | | | | | 34,772 | | | | | | | | | |
| Chapin ore (natural) | | 1.60 | 177 | 2.64 | 292 | 51.76 | 5,725 | 1.18 | 131 | 72.64 | 80.34 | 1.10 | 122 | | 3.15 | 8.00 |
| Michigan limestone | 4 | 54.60 | 5,198 | 0.88 | 84 | 0.20 | 19 | | | | | 0.30 | 28 | | | 1.50 |
| Calcined dolomite | 3 | 48.58 | 1,215 | 32.58 | 815 | 0.38 | 10 | | | | | 1.49 | 37 | | 15.54 | |
| Fluorspar | | 250 | 8 | 0.38 | 1 | | | | | | | 1.15 | 3 | 92.53 | | |
| $SiO_2$ from furnace structure | | | | | | | | | | | | | | | | |
| Total entering furnace | 47 | | 6,572 | | 1,191 | | 101,112 | | | | | | 190 | | | |
| Total steel in bath | 40 | | | | | 99.59 | 99,094 | | | | | | | | | |
| Tapping slag, 99.71 per cent | 36 | 4,608 | 6,572 | 8.32 | 1,192 | | 1,918 | 17.14 | 2,474 | | | 1.32 | 190 | | | |
| Total output | 76 | | | | | | 101,012 | | | | | | | | | |
| Unaccounted for | +29 | | | | | | ·100 | | | | | | | | | |
| Metalloids oxidized | | | | | | | 100 | | | | | | | | | |

Heat in superheat = 885 (2800 — 212) 0.81 = $1.85 \times 10^6$
Total = $2.82 \times 10^6$ B.t.u.

Decomposition of limestone:
Heat of formation $CaCO_3$ per lb. = 772 B.t.u.
Total limestone = 9520 lb.
Total heat required = $9520 \times 772 = 7.35 \times 10^6$
Moisture 1.5 per cent = 142
Total heat to make steam = $142 \times 1092 = 0.16 \times 10^6$
Heat in superheat = $142 \times 2096 =$ $0.30 \times 10^6$
Total = $0.46 \times 10^6$ B.t.u.

Decomposition of improperly burned dolomite:
Total weight of dolomite = 2500 lb.
Volatile = 15.54 per cent = 389
Assumed 98 per cent = 381 exists as $CO_2$
To drive off $CO_2$ = 1756 B.t.u. per lb.
Total heat to drive off $CO_2 = 1756 \times 381 = 0.67 \times 10^6$

#### THERMOPHYSICAL CHANGE

Hot metal = 65,000 lb., temperature = 2474° F.
Tapping temperature = 3080° F. includes emissivity factor
Temperature rise (3080 — 2474) = 606° F.
Specific heat = 0.2
Heat absorbed = $65,000 \times 606 \times 0.2 = 7.88 \times 10^6$
Scrap = 35,000 lb. Temperature = 62° F.
Melting temperature scrap = 2795° F.
Heat required to bring to melting temperature = $35,000 \times 2733 \times 0.16 = 15.30 \times 10^6$
Latent heat of fusion = 72 B.t.u.
Total heat of fusion = $35,000 \times 72 = 2.52 \times 10^6$
Heat to raise to temperature of bath = $(3080 - 2795) \times 35,000 \times 0.2 = 2.00 \times 10^6$
Total heat = $19.82 \times 10^6$
Total heat in molten slag
Heat in tapping slag = $14,318 \times 1066 = 15.26$ B.t.u.
Total heat absorbed = $74.60 \times 10^6$ B.t.u.

### Heat Generated

Oxidation of carbon, weight = 2667 lb.
Heat of formation of CO from C per lb. = 4374 B.t.u.
Heat generated = $4374 \times 2667 = 11.67 \times 10^6$
Oxidation of manganese, weight = 645 lb.
Heat of formation of MnO = 2984 B.t.u.
Heat generated = $2984 \times 645 = 1.92 \times 10^6$
Oxidation of silicon, weight = 488 lb.
Heat of formation of $SiO_2$ = 11,693 B.t.u.
Heat generated = $11,693 \times 488 = 5.71 \times 10^6$
Oxidation of phosphorus, weight = 435 lb.
Heat of formation of $P_2O_5$ = 10,825 B.t.u.
Heat generated = $10,825 \times 435 = 4.71 \times 10^6$
Heat of formation of slag, weight = 14,435 lb.
Heat of formation of slag = 191 B.t.u.
Heat generated = $191 \times 14,435 = 2.76 \times 10^6$
Total heat generated = $26.77 \times 10^6$ B.t.u.

### Authorities for Constants Used

#### THERMOCHEMICAL CHANGES

Iron oxide reduction—Richards
Decomposition of limestone—U. S. Bureau of Standards
Oxidation of C, Mn, Si, P—Richards, LeChatelier, Berthelot, Thomson
Formation of slag, calculated using Richards' values

#### THERMOPHYSICAL CHANGE

Specific heat, pig iron—0.1665—Oberhoffer
Specific heat, soft steel—0.16—Meuther
Latent heat of fusion, pig iron—Hutter
Latent heat of fusion, steel—average value—Jetner, Richards, Brisker
Heat in molten slag—Springorum

### Thermal Balance Sheet

#### HEAT ABSORBED

Red. of oxides of Fe = 20.34
Absorp. moist. of ore = 2.82
Decomp. of limestone = 7.35
Absorp. moist. of limestone = 0.46
Decomp. of dolomite = 0.67
Heat in molten slag = 15.26
Heat added to mixer metal = 7.88
Heat added to scrap = 19.82

#### HEAT GENERATED

Oxidation of C = $11.67 \times 10^6$
Oxidation of Mn = 1.92
Oxidation of Si = 5.71
Oxidation of P = 4.71
Heat form. slag = 2.76

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Balance heat to be supplied by combustion of gases in furnace $= 47.83 \times 10^6$
Total B.t.u. $= 74.60 \times 10^6$

THERMAL EFFICIENCY OF BATH

Thermal efficiency of furnace = 17.3 per cent
B.t.u. in gas per pound of coal = 10,625

$$\text{Total B.t.u. to be supplied in producer gas} = \frac{47.83 \times 10^6}{0.173} =$$

$276.47 \times 10^6$ B.t.u.
Total coal burned = 26,021 lb.

Constructing a slag in this manner gives only the combined percentages of ferrous oxide and manganous oxide, so that it is necessary to compute on the basis of working conditions the quantity of residual manganese carried by the bath for different conditions of slag volume. With this amount ascertained, the manganese in the slag is the total manganese charged less that in the bath less that carried away by the furnace gases. The difference between the manganese in the slag, expressed as manganous oxide, and 27 per cent is the ferrous oxide in the silicate slag.

The method of calculating the residual manganese is as follows: The residual manganese remaining in a bath, after the reactions have come to a condition of equilibrium, is a function of the manganese available (i.e., the manganese charged less that which has been oxidized and carried away with the waste gases) the character of the slag, and the relative volumes or masses of slag and bath. The character of the slag determines the chemical affinity for manganese and represents the amount in the slag, other things being equal. But superimposed upon this is the relative masses of slag and bath, for a large slag volume will leave lower manganese residuals than one of similar analysis but smaller volume. For slags of similar analysis, it is considered that the manganese available will divide according to the relative masses.

$$\text{Let} \quad \frac{\text{Weight manganese in bath}}{\text{Weight manganese in slag}} = x$$

$$\text{and} \quad \text{and} \ \frac{\text{Weight of bath}}{\text{Weight of slag}} = s$$

So it becomes necessary to determine the relation between x and s which is a measure of the chemical affinity and will remain essentially constant for a given type of slag. It was found, from practice, that when working with slags of this type that $s = 22.5x$.

Let $a$ = weight of manganese in bath;
$b$ = weight of manganese in slag;

$$\frac{a}{b} = x$$

$$a + b = y = \text{total weight of manganese available.}$$

$$b = y - bx \qquad b = \frac{4y}{1 + x}$$

$$a = y - \frac{y}{1 + x} \qquad a = \frac{xy}{1 + x}$$

In all cases the ratio of bath to slag is known, so that it becomes possible to figure all the residuals on the same basis.

The effect of the various percentages of residual manganese on the finishing additions of manganese made in the ladle is shown in Table XV. The calculated amounts of pure manganese correspond to results obtained in actual practice.

(Concluded on Page 258)

TABLE XIII — SLAG RATIOS

| | Silicate Slag | | | | | | Phosphate Slag | |
|---|---|---|---|---|---|---|---|---|
| | $SiO_2$, Per Cent. | $FeO$ + $MnO$, Per Cent. | $Al_2O_3$ + S, Per Cent. | $CaO$ + $MgO$, Per Cent. | $\frac{\text{Sil. Slag}}{SiO_2}$ | $\frac{CaO + MgO}{SiO_2}$ | $\frac{CaO}{P}$ | $\frac{\text{Phos. Slag}}{P}$ |
| Dichmann ........ | 21.0 | 26.00 | 4.0 | 49.00 | 4.78 | 2.33 | 3.61 | 5.9 |
| In normal heats, values used .... | 19.0 | 27.00 | 2.0 | 52.00 | 5.26 | 2.74 | 3.61 | 5.9 |
| In excess limestone heat ........... | 14.0 | 27.00 | 2.0 | 57.00 | 7.10 | 4.00 | 3.61 | 5.9 |

TABLE XIV — ANALYSIS OF THEORETICAL SLAGS

| | $P_2O_5$ Per Cent. | $FeO$ Per Cent. | $MnO$ Per Cent. | $SiO_2$ Per Cent. | $Al_2O_3$ + $TiO_2$ Per Cent. | $CaO$ Per Cent. | $MgO$ Per Cent. | S Per Cent. |
|---|---|---|---|---|---|---|---|---|
| Scrap ............ | 3.83 | 17.26 | 7.07 | 17.15 | 0.52 | 44.29 | 8.67 | 0.25 |
| Standard iron, high $SiO_2$ ........... | 2.58 | 19.51 | 5.69 | 17.94 | 1.41 | 43.46 | 9.77 | 0.25 |
| Standard iron, low $SiO_2$ ........... | 3.18 | 18.32 | 6.70 | 17.61 | 1.62 | 41.77 | 11.52 | 0.25 |
| High-manganese iron, high $SiO_2$.. | 2.47 | 15.44 | 9.84 | 17.80 | 1.43 | 43.12 | 9.54 | 0.25 |
| High-manganese iron low $SiO_2$... | 3.12 | 13.11 | 11.72 | 17.48 | 1.69 | 41.44 | 11.38 | 0.25 |
| Excess limestone.. | 1.91 | 21.12 | 4.54 | 13.39 | 1.16 | 50.13 | 7.51 | 0.25 |
| High-silicon iron.. | 1.42 | 22.37 | 3.64 | 18.31 | 1.09 | 46.24 | 6.18 | 0.25 |
| High-phosphorus iron ............ | 6.96 | 17.28 | 4.87 | 15.60 | 1.33 | 46.08 | 8.32 | 0.25 |
| Average not including high limestone .......... | 3.36 | 17.61 | 7.07 | 17.41 | 1.30 | 43.77 | 9.34 | 0.25 |

# MATERIAL HANDLING

# Straight Line Production

## Woodward Iron Cuts All Unnecessary Corners in Reducing Raw Materials to High Grade Metal

By F. J. CROLIUS

PART I.

THE making of iron in the Birmingham district is first, last and always a great material handling business.

At the Woodward Iron this business finds its lowest common denominator. To best understand the problem a glance at the territorial map will be enlightening. On the right will be found Red Ore Mountain, well named as its appearance from a distance and upon closer approach will testify. "Red Ore" is historical; decades before the production of iron was even thought of, the Indians, probably the Seminoles wound their trails through the pine forests, and from the very surface found the disintegrated red material which they mixed with animal oils to paint their faces in preparation for the war-path. Recent years have recognized this early incident thro' beautiful pageantry staged on these historical slopes themselves by the children of the vicinity. This pageant is intensely interesting, and forms a definite link in the social development of this community.

On the left looking from the south will be found a broad expanse of coal field dotted at close intervals with shafts and slopes. In the very center stands Woodward, the operating core of a railroad organization which, receiving ore at one end and coal at the other, blends them at the coke oven and blast furnace unit midway from either end. One familiar with iron production will note the fact that limestone receives scant mention in this citation of essential raw materials. And herein lies the great difference between northern furnace practice and Birmingham.

The Red Ore (Clinton Iron Ore) is lower grade, that is ferric content, than northern ores, but it is self-fluxing, carrying with it's 38 per cent iron oxide, some 20 per cent lime. The silica content varies with location, being lowest at Woodward, the centre of the outcrop, shown in Fig. 2 which totals some 10 miles, and increasing both toward the north and south. This silica proportion will have an important bearing on the future of this district.

### Clinton Ore.

The Clinton iron ore, so named from its typical occurence in sedimentary rocks at Clinton, N. Y., and in strata of equivalent age in other parts of North America, belongs to the class of iron oxides known as red hematite. It includes the structural varieties known as red fossil and oolitic ore. The mass of the ore is amorphous red hematite mixed with calcium carbonate, silica, alumina, magnesium carbonate, and other minerals in minor quantities.

The structure and mineralogy of the Clinton ore with its associated minerals occurs in beds analogous to strata of sandstone, shale, and limestone, and interbedded with such rocks.

The fossil ore consists of aggregate of fossil organic forms such as bryozoans, crinoids, corals, and brachiopods. These forms were evidently at one time principally calcium carbonate, and they have been replaced partly or wholly by ferric oxide. The fossil material, much of which consists of broken and water-worn fragments, evidently was gathered by the action of waves and currents into beds, and subsequently cemented together by calcium carbonate and ferric oxide. More or less clay material has been likewise included in the beds during their formation, and this commonly exists as thin seams of shale.

The oolitic ore consists of aggregate of flat grains with rounded edges, somewhat of the size and shape of flaxseeds. These grains generally lie with their flatter sides parellel to the bedding planes of the rock, and the mass is cemented by ferric oxide and more or less calcium carbonate.

### Chemical Composition.

Conditions of blast furnace practice define the grade of material that may be regarded as an ore. For instance, a lower limit of metallic iron and a higher limit of impurities may be allowed in a limy ore than in one that contains but little lime. In localities where brown iron ores are available for mixing with Clinton ores, an ore of the Clinton class can be used as a flux in many instances, although it runs so low in iron and so high in lime that it might not be regarded as acceptable in districts where no brown ore can be used. In general, the hard and semihard ores used today in the Birmingham district range in percentages of major constituents as follows: Metallic iron, from 32 to 45 per cent; lime oxide, from 5 to 20 per cent; silica, from 2 to 25 per cent; alumina, from 2 to 5 per cent; magnesia, from 1 to 3 per cent; phosphorus, from 0.25 to 1.5 per cent; sulphur, from a trace up to 0.5 per cent; and water, from 0.5 to 3 per cent. The ore therefore is of non-Bessemer grade. Small quantities of manganese are found in the ore in places. The content of this mineral seldom exceeds 0.25 per cent. In the soft ore the lime generally runs less than 1 per cent, so that the percentages of the other constituents are proportionately higher.

### Hard and Soft Ores.

The terms "hard" and "soft," as applied to the two principal varieties of Clinton ores, hardly express the facts, for the distinction between the two varieties in question is based upon differences in their chemical composition rather than upon differences in hardness.

Most of the red ore of Alabama is, in its typical or "hard" variety, a highly limy ore. The ore beds are usually overlain and underlain by comparatively impervious shales; and in most places dip at rather high angles. These conditions favor the penetration of the ore, near the surface at least, by percolating water. The result is that near the outcrop, and for some distance down the slope, the lime carbonate of the original ore is largely or entirely leached out. This removal of one constituent of course increases the relative percentages of the remaining less soluble ingredients, while it renders the ore more porous and friable. The resulting "soft ore" is therefore very low in lime, and correspondingly high in iron oxide. A secondary effect of the change, shown best where the cover is heavy and the dip low, is that the overlying shales settle down slightly as the bulk of the ore is reduced, so that on the outcrop the ore bed often has less than its normal underground thickness.

The Woodward Iron Company's slopes 2, 3, and 1 are located in the SW. ¼ sec. 36, T. 18 S., R. 4 W., and the SE. ¼ sec. 2, T. 19 S., R. 4 W. Besides these slopes there was in 1906 in the NW. ¼ NW. ¼ sec. 1, T. 19 S., R. W., a temporary slope or scram said to be mining 5 ft. of siliceous soft ore from the lower bench of the Big seam. Slope 3 has been laid out a little farther southwest, or about 600 ft. from No. 2. This slope is reached by a drift beginning in the upper portion of the Chickamauga limestone. At Woodward mine No. 2 the present mining is on the upper bench of the Big seam, which is about 10½ ft. thick here. In places 1½ to 2 ft. of the bed are left at the top as roof, since this portion of the bed is rather siliceous and makes a better roof than the sandstone above the bed. Between the upper and lower benches of the Big seam is 18 to 24 in of shale. This slope was down about 3500 ft. in January, 1924, nearly all the distance in hard ore. The normal dip is 28 deg. to 30 deg., but at about 185 ft. from the entrance to the slope the strata flatten out for a short distance and again resume their normal dip. The rocks are folded and fractured noticeably in the vicinity of the entrance, and a small fault is reported to occur in one of the right-hand entries, now robbed. The ore at this place is reported to average slightly leaner in iron and lime than at the No. 1 slope, three-fourths of a mile farther southwest.

Woodward mine No. 1 is located near the northwest foot of Red Mountain at Tanyard Gap. The

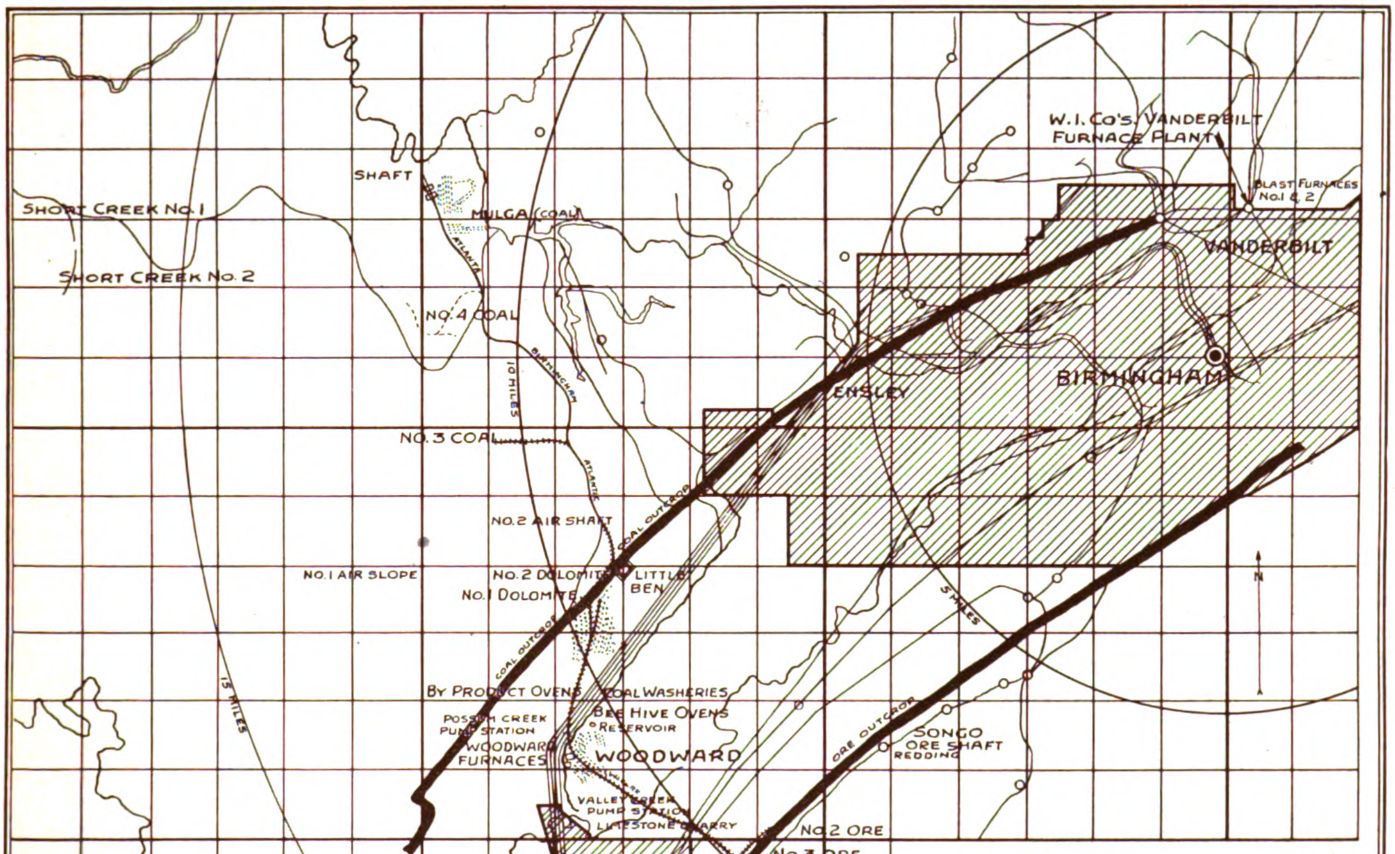

FIG. 2—*The striking feature shown by the general map of the Birmingham District is the paralelling of the outcrops. On the eastern side lies the ore, on the western is found the coal. No ore or coal docks, no ice-bound winter lake seasons, no enormous ore bridges, rairoad and water transfers needed here.*

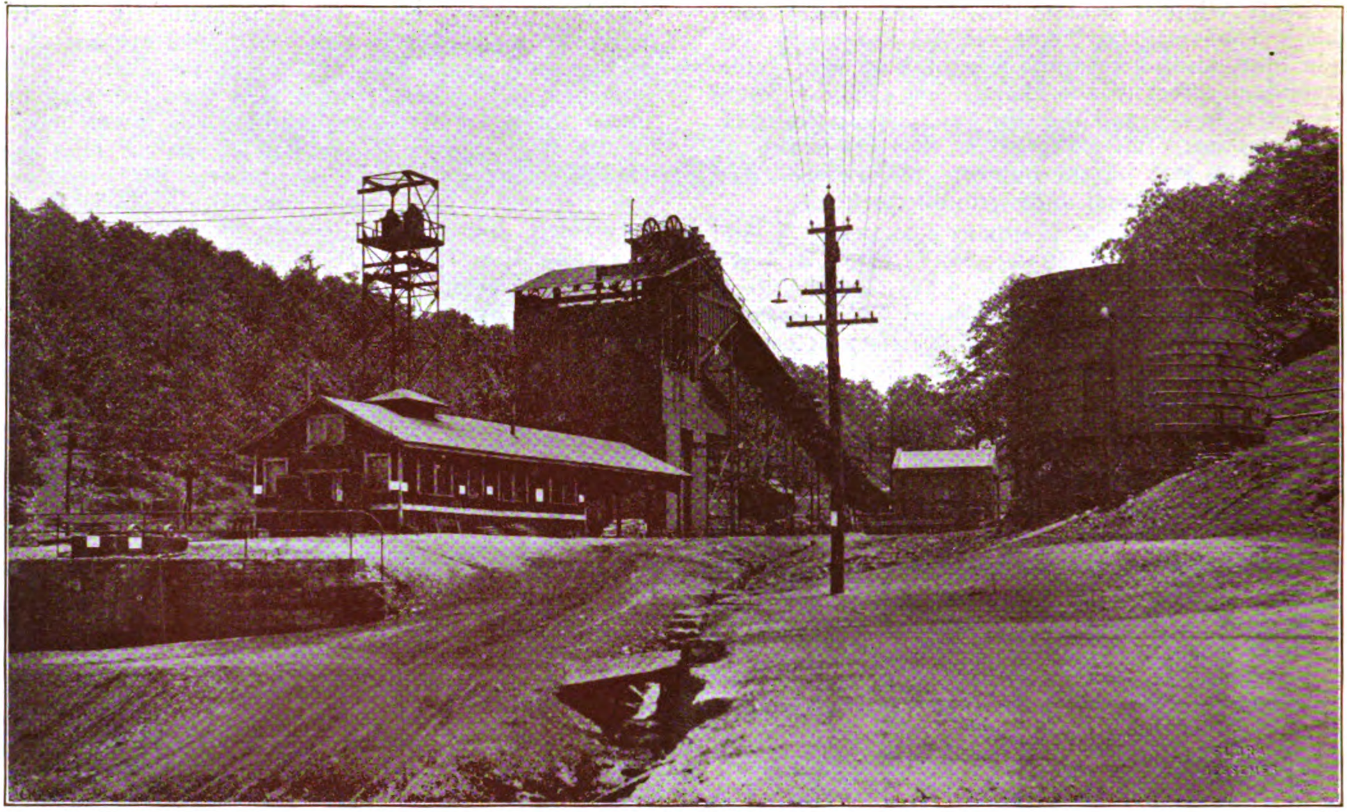

FIG. 3—*It would be difficult to exaggerate the natural beauty of these mines as located. In the midst of healthy pine woods with occasional mistletoe, appearances and conditions are distinctly different from the mines of any other district.*

Hickory Nut and Ida seams and the Big seam, with its upper and lower benches, are present here, and also a shaly, ferruginous horizon which may represent the Irondale seam. The Hickory Nut seam never was mined, but the Ida seam yielded a thickness of 3 ft. of soft ore, carrying about 40 per cent iron. This was stripped for some distance along its outcrop. In the slope the upper bench of the Big seam is about 12 ft. thick. Nine and one-half to 10½ ft. of ore are obtained. Occasionally a thin parting of shale is found 15 to 18 in. from the bottom or top. The top 18 in. of the bed are generally left for a roof, as at slope 2. The dip of the rocks is variable here also. On the outcrop it is 34 deg., but within the slope it flattens out and ranges between 20 deg. and 28 deg., until at the lower end, a distance of about 1,500 ft. from the outcrop, the beds abruptly bend downward at an angle of 40 deg., and the ore is faulted downward a distance reported to be about 15 ft. The direction of this fault is N. 35 deg. E., as observed in the slope, and its hade is 80 deg. to the down throw.

"Water channels" passing along fractured beds are reported to have been encountered in several places, for instance in the eleventh right entry, and adjacent to these the ore was soft but surrounded by hard ore.

The bottom ledge of the Big seam is here about 4¼ ft. thick and carries where soft 45 to 47 per cent iron, but less than 35 per cent of iron where hard. Under present conditions it is not considered worth mining, since it is poor in lime. The ore from the upper bench at these mines contains enough, or in places a trifle more than enough, lime to be self-fluxing. Systematic chemical analyses are reported to have been made of samples of ore taken every few feet from the outcrop to the bottom of the slope and from each entry to the right and left of the slope. The composition of the ore has been found to vary considerably from place to place, and the degree of variation has been found to be as great within a few yards as it is between remote parts of the mine, but the average run of the mine has been remarkably regular since the hard ore was reached. The hard ore "slacks" when left standing several years in pillars, making it necesary to rob promptly to obtain the pillars.

There is indicated a total of 358,470,700 long tons of ore at present available in the main portion of the Birmingham district, and it is probable that one-half billion tons would be reached by any estimate that considered carefully the reserves in the other divisions of the district not included within the present estimate. The estimates show also a reserve of 146,024,700 long tons of ore in the lower bench of the Big seam, and of 292,401,400 long tons in the main part of the Big seam in the eastern part of the Shades Valley—a total of 438,426,100 long tons of red ore not available under present conditions.

When it is considered that the annual production of red ore in Alabama in 1923 was exactly 5,169,782 long tons, and that the production has not increased rapidly in recent years and does not promise to increase rapidly in the near future, the results of the estimate indicate that the iron ore at present available in this district promises to last more than 100 years longer at the present rate of output. The foregoing estimate, which gives a grand total of 796,896,800 long tons of red ore in the Birmingham district, as compared with the preliminary estimate of 1,000,000,000 long tons of red ore in Alabama, previously published by E. C. Eckel, appears fairly conservative, when it is recalled that the Birmingham district probably contains 80 per cent of the red ore of the State that can be regarded as possibly workable. On the other hand, the preliminary estimate made by Eckel of 1,000,000,000 long tons of red ore in Alabama, including as it did much ore probably carrying 25 to 30 per cent metallic iron, and occuring in seams at present regarded as too thin to be profitably worked, but of possible future value, appears to be consistently supported by the present estimate of ore reserves in the Birmingham district.

**System of Mining.**

The room-and-pillar system of mining is employed, with final robbing of the pillars. From both sides of the main slope entries or headings are driven in the ore at regular intervals of 50 to 65 ft., thus dividing the mine into levels or slopes which are worked independently. The distance between the centers of the headings is determined by twice the length to which it is desired to drive the rooms. For instance, if it is desired to drive rooms 30 ft. in length up the dip from the heading the headings are driven 60 ft. apart. The size of the rooms depends on the character of the roof and thickness of the ore seam. The grade of the main slope varies with the dip of the beds, whether it is driven down the dip or with the jointing of the ore. The dips range from 15 deg. to 45 deg. as observed in the various slopes of the district, but they range mostly between 18 deg. and 30 deg.

Two methods of haulage are in use in the ore mines. Under the older method the trams of ore in trains of 5 to 8 cars each are hauled up the slope by cable. The floor of the slope corresponds with the bottom of the ore that is mined. With tram haulage the headings are sometimes offset 15 to 25 ft. in order that the switches on opposite sides may not come at the same point on the main slope track. The later method of haulage employs the skip, or steel slope car, which carries ore from the mouths of the headings up to the tipple. With skip haulage the right and left headings are generally opened directly opposite each other and the main slope is depressed about 8 ft. below the bottom of the worked ore bed, enough to give headway for dumping the pit cars into the skip. The tracks in the headings are laid on the floor of the workable bench of ore. The main slope is therefore 16 to 20 ft. high, while the headings are the height of the workable portion of the ore bed, unless this is less than enough to provide head room. The width of headings is about 15 feet for 60 to 100 feet from the man slope, beyond which it is increased to 25 or 30 feet, the width of the rooms. The portions of ore remaining after driving the headings, cutting out rooms and connecting the headings by "break throughs" or air ways about 100 feet apart, are called pillars. The pillars are finlaly taken out or robbed after the mine workings have been extended below as far as is advisable.

Since the presence of water in a mine is due to fractures in the rocks, mines in localities of slight folding or faulting usually encounter more or less water, while those in undisturbed strata may be practically dry. The water which collects in the sumps is pumped out by air or steam, principally by air, since air has also to be employed extensively for drilling.

The ventilation of these iron-ore mines is much more easily effected than that of a coal mine, since there are no suffocating or inflammable gases and no combustible dust. In dry mines there is some ore dust and, of course, considerable powder smoke

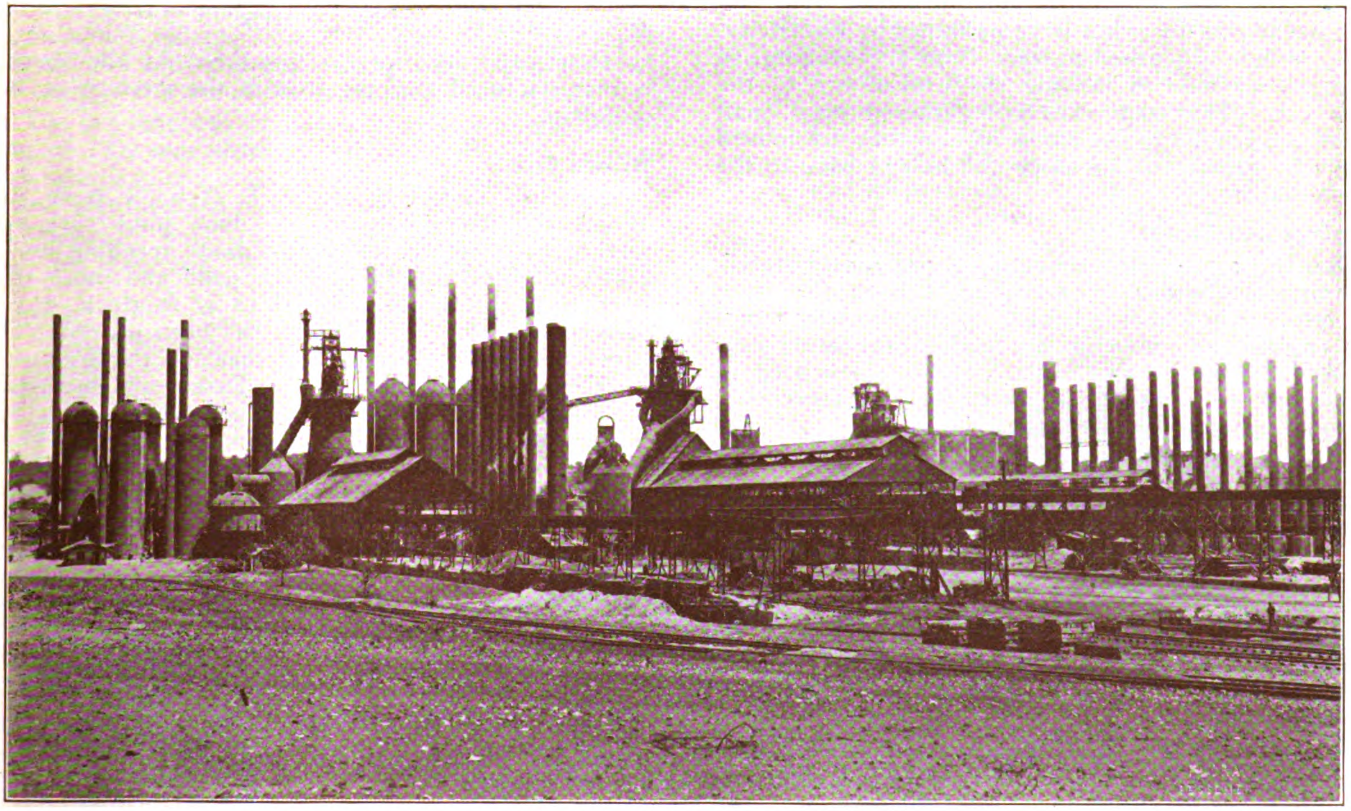

FIG 4—*A panarama of the three blast furnaces at Woodward; two more furnaces located at Vanderbilt, distant about eight miles complete a producing capacity of 1,500 tons of iron per day. This furnace plant is a model of neatness and safety.*

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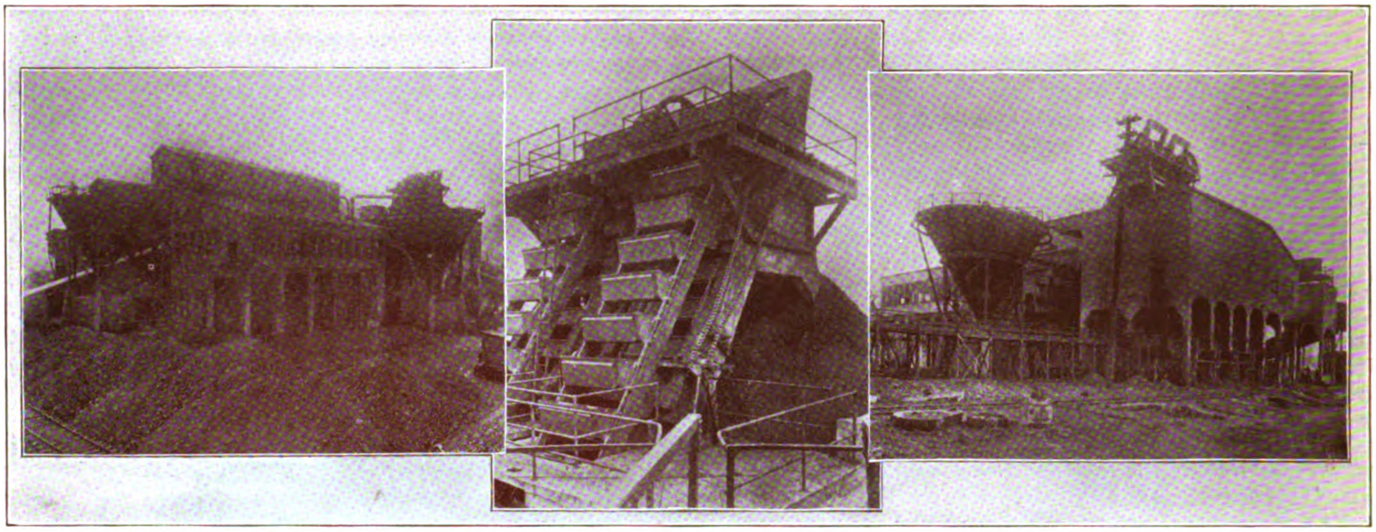

FIG. 5—*This Link-Belt washer handles more than 5000 tons of coal per day. The problem involves an apron conveyor under the 2500-ton concrete hopper which receives the coal from the railroad cars. The apron conveyor empties onto a 42-in. belt conveyor discharging into two 12 x 17 Bradford breakers. From thence, over a belt-conveyor, the coal proceeds to a G. D. elevator, which carries it up and into the raw coal bins. The coal is then drawn off into a series of double plunger jigs, from which it is sluiced off to the wet coal tank, thence into two large bucket elevators and into the wet coal bins over the tracks. Between the wet coal tanks and the bins is a settling cone, which cares for the overflow of the wet coal tanks. This construction conserves water, a precious element in the Birmingham district, to the last degree; the only considerable loss being due to incidental evaporation.*

from blasting. The currents of air entering the mine slope naturally pass downward and are divided and drawn laterally into the headings, and the air supply is further augmented by the exhaust from the air drills, which also stimulates the circulation. The mines are illuminated by electric lamps. Electric apparatus is employed for signalling, and telephones are installed at stations underground.

Drills are operated by air under a pressure of 75 to 80 lb., and the ore is shot down by dynamite fired usually by fuse, but in some mines by electricity. The ore face is worked upward from the heading, so that gravity aids in moving the broken ore to the tram car. The tram cars are gathered into small trains and hauled to the slope, or else they are moved singly by gravity to the slope and hauled back to the face by mule.

### Haulage and Power.

Raising ore to the surface is, as previously stated, accomplished either by dumping it from the tram car into a skip which is hauled up the slope by winding engine and cable or by hauling the mine cars themselves out by the cable. Steel cables used in the slopes are generally 1⅛ to 1½ in. in diameter.

Skip haulage has supplanted train haulage in all the slopes.

### Production and Consumption of Iron Ore.

Since 1894 Alabama has held third place among the iron-producing States. In 1907, a normal year in the iron industry, her total production of iron ore amounted to 4,039,453 long tons, composed of 3,144,011 tons of red hematite and 895,442 tons of brown hematite.

In 1920, the total production of iron ore in the State of Alabama was 5,833,317 long tons, valued at $15,993,985. Of this total production 5,169,782 tons was red ore, and represented 86 per cent of the production of ore for the state. This tonnage constituted 7.64 per cent in 1920 of the total ore produced in the United States.

It will be noticed that in a year of industrial depression, such as 1908, the production from the Birmingham district did not suffer as did other districts in the State. The production of brown ore in the Birmingham district actually showed a large increase in 1908, due in part to the reopening of the mines at Champion. The average value for red ore per ton is between $1.05 and $1.10, and has not suffered much change in the last three years. The average value for brown ore per long ton in 1908 was about $1.36, as compared with $1.55 for 1907.

Practically all the ore produced in the district is manufactured into pig iron in the vicinity of Birmingham.

### Brown Ore.

Near the middle of sec. 9, T. 21 S., R. 6 W., the Woodward Iron Company has done some very systematic prospecting, and an ore body trending northeast-southwest, 300 to 1,500 ft. wide and more than 4,000 ft. long, ranging from 1 to 32 ft. thick, but in general from 4 to 15 ft. thick, has been proved. The cover is composed in part of loam of the Lafayette formation and possibly some Tuscaloosa materials, the total thickness being in general between a few inches and 20 ft., but running in one place to 47 ft. A few holes struck no ore at all, and several encountered very hard ore at water level and were driven no deeper, so that it is not known just how thick the ore may be at those places. Limestone, probably Knox, and residual clay were found below the ore in several pits. Clays of the Tuscaloosa formation are found in abundance just northwest of the ore-bearing ground.

In one prospect the ore was found to be highly manganiferous. Below 43 ft. of loam was found 3 ft. of brown ore, then 5½ ft. of clay, then 4 ft. of manganese ore and brown ore mixed, and the pit stopped in ore and water. Analysis showed the material in the lower bed to carry 45.8 per cent insoluble matter, 15.2 per cent iron, and 18.2 per cent manganese.

In connection with the prospecting of this property, a detailed topographic map on a scale of 100 ft. to 1 in., with 5 to 10 ft. contour intervals, was prepared. By means of this map it has been possible to select the best sites for a storage dam, pump house, washer, and to lay out pipe line, railway tracks, settling pond, etc., besides plotting the location of the test pits at their relative altitudes.

This property is connected with the mineral division of the Louisville and Nashville Railroad at Chamblee by a spur about 2 miles in length.

In January, 1909, the Woodward brown-ore workings consisted of several open cuts in the hillsides at or above the level of the private railroad line. The ore is exposed in places to a depth of 15 ft. No ore is exposed to the underlying limestone or its residual clay. Little or no stripping is required in places, while in others 10 ft. of stripping is necessary. The cover normally consists of a reddish residual clay, mixed with surface debris. Some red loam of the Lafayette is present. The ore consists of (a) "wash ore"—that is, of loose, small-sized fragments, and loose irregular-shaped masses, all imbedded in reddish clay or reddish to light-yellow sand and clay—and (b) masses of hard, compact ore that are continuous for some distance. Associated with and inclosed by these large masses of ore are pockets of tough yellow clay, showing faint laminations in places. This clay and the beds of laminated Cretaceous clay that are also found near the ore in several railroad cuts are indiscriminately termed "white horse" by the miners. No true "white horse" or clay bottom was observed in these workings.

The massive ore is so compact and hard that it can be worked only very slowly and with great difficulty by pick and shovel, and blasting is therefore employed. Within masses of this ore were noted cavities in which redeposition of limonite had taken place through the action of percolating water, and some of the cavities contained fine-grained yellow sand.

The ore that was produced from here at the beginning of 1909 was worked out by hand in connection with blasting, and was screened by hand over an inclined, stationary screen of coarse mesh.

There are more than 25 operating ore mines on Red Ore Mountain. The descriptions given will cover them all, very similar methods and equipment being employed universally.

In both the Woodstock and the Champion areas the brown ore is mined from open cuts.

The steam shovels used in brown-ore mining range from 20 to 60 tons in weight, and handle from 1¼ to 2½ cubic yards per dipper.

The brown ore is separated from the impurities that are mined with it, such as loam, sand, gravel, and clay, by a system of breaking, washing, picking, and screening.

A description of the latest washer to be installed in the Woodstock district, that of the Woodward Iron Company, at Docray, will serve to illustrate the standard method and equipment employed for cleaning and concentrating the brown ore. Gravity carries both ore and water through the whole process from the top deck of the washer until the cleaned ore is delivered to the railroad cars and the water to the settling pond. The washer is built in two sections on a hillside above the Louisville and Nashville Railroad track. Ore is brought from the cuts in steel, bottom-dump cars. The tracks of the mine road terminate on the top deck of the washer. Three cars may be dumped at once on this deck. The ore falls through to a steel-shod incline below, 80 by 20 feet, pitching 30 deg. The ore slides down the incline over a bar screen 12 feet wide, pitching at the same angle as the incline. The bar screen is constructed of steel rails, 4 inches by 12 feet, spaced 3 inches apart.

The screenings fall into a trough or flume of water. The rejects fall on a conveyor belt, 36 inches by 80 feet. This belt may serve as a picking belt if necessary. The belt discharges into a No. 7½ Gates gyratory crusher, which discharges into the same flume that received the screenings. This flume is lined with a U-shaped chilled-iron channel, 27 inches wide at the top and 13½ inches high inside. The flume is 96 feet long, pitches about 2¼ feet in 12 feet, and is fed by a 6-inch stream of water under about a 50-foot head. This flume discharges its ore into a revolving conical screen 12 feet long by 3 and 3½ feet diameters. The axis of the screen is horizontal with the small end toward the flume. Inside the screen is a spiral retarder, and the ore that passes the perforations, which are 1½ inches in diameter, is divided between two sets

FIG. 6—*Woodward is justly proud of the railroad bearing its name. The operation comprises some 45 miles of trackage, and employs 12 modern locomotives with 232 standard guage cars. This is the connecting link between Ore-Mines, on the one side, Coal Mines on the other, Plant Operations near the centre, and Shipping Facilities, adjacent. Above is shown big No. 33, a Sante Fe type locomotive, latest addition to Power Plant, hauling a train of coal.*

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of washers below. The rejects from the screen fall on a conveyor belt and are carried to a chute which divides the material between two revolving sand screens below. Each of the two log washers consists of two logs 29 feet long, octagonal in section, 18½ inches between faces. The ore after passing through the log washers goes also to the sand screens. These two screens are of wire, with ⅛-inch mesh. They are 6 feet long, conical in shape, 31 and 37 inches in diameter at the ends. The ore from each of the sand screens passes on to a picking belt, 36 inches by 30 feet. From these belts the lumps of foreign material, such as clay, chert gravel, sandstone, etc., are removed by hand. The picking belts discharge into a storage bin built directly over the Louisville and Nashville Railroad track. This bin holds two carloads of ore, and dumps into cars below. The muddy waste water passes to a mud flume beyond the railroad track. This mud flume carries the waste 1,500 feet up a small valley to the head of the settling pond, which is about one-half mile in length. Water is supplied from a storage reservoir above a dam on Kennedy Creek, about three-fourths mile below the washer, and the clear water from the lower end of the settling pond will be collected also by this storage reservoir. Two pumps with 6-inch suction and 5-inch discharge will be employed, and the water will be pumped to two 25,000-gallon tanks on the hill about 50 feet above the washer. This washer is designed to handle 500 short tons of ore in 10 hours.

**Transportation.**

The ore broken to conveniently small charging sizes, falls directly into the broad guage railroad cars, which convey their part of the burden directly to the furnace stock-house. This is a substantial concrete structure parallelling the straight line arrangement of the five blast furnaces, double tracked the entire length. Hand operated ore and coke bin doors feed by gravity into stock lorries, which complete the transit to the furnace skip. It will be noted that no ore-bridges are employed, the source of supply being contiguous without the handicap of weather, or seasonal limitations, no trans-shipments are necessary, and gravity being brought into play throughout the journey. The only power required is the current on the mine hoist motor 750 hp., on the mine locomotives, on the fans and pumps and air compressors, plus the relatively small amount of power called forth in hauling the empty cars back up to the mine mouth level. Nothing could be simpler, nore free from surplus labor than the entire operation. Forty-two hundred men produce 1400 to 1500 tons of foundry iron per day, performing all the functions of mining both ore and coal, its transportation, preparation conversive into coke, and reduction into iron, shipped to destination. One mine, "Redding", produces 1,400 tons of ore per day. Except for the color of the buildings, it would be difficult to distinguish the coal mines from the ore mines. The fuel used in the blast-furnaces at Woodward, and at all Birmingham furnaces, is coke made exclusively from Warrior Field coal.

ESTIMATED TONNAGE OF COKING COALS, WARRIOR FIELD, ALABAMA

| | Short tons |
|---|---|
| Mary Lee group | 3,207,168,000 |
| Pratt bed | 827,360 000 |
| Brookwood group | 160,800,000 |
| | 4,195,328,000 |

In this computation it is assumed that approximately 100,000,000 tons of Pratt coal have been worked out, leaving a remainder of 827,360,000 tons as given above. Assuming that 80 per cent of the total coal in the ground will be mined, the yield would be 3,366,262,400 short tons. Assuming further that the coal will yield 60 per cent of coke, the total amount of coke that could be made from this coal would be 2,019,757,240 short tons. On the basis of 1.8 tons of coke to a ton of pig iron, which is derived from a statement of furnace operations of a single company for April, 1906, this quantity of coke would produce 1,122,087,355 short tons of pig iron. To produce this amount of iron at the present rate of production would take 625 years, but if the production should be doubled every 20 years it would take only 87 years.

**Similar Methods.**

Here again slope and shaft mining is employed. The 56-in. vein of bituminous coal lays at about the same angle as the iron, but in a different plane. Mining at Dolomite, the town site name of one of the most important mining operations. At Dolomite, the present working is about 1200 ft. The coal is elevated at about 30 deg. angle by a newly completed motor driven hoist, which is a model of substantiability and completeness. Perhaps the most interesting feature of the coal hoisting mechanism is the Rolls-Right Tipple, at the top. The railroad tipple, belies the suggestion employed in its name to the Rolls-Royce Motor car, that is in appearance, but in its effectiveness, it supercedes it. Five 3600 lb. car loads of coal find their journeys end into the light structural tunnel which forms the frame of the railroad. The simple tripping of a latch causes the unbalanced load up the tipple platform rails to whirl downward, not through a complete circle, however, as in the rotary car dumper so well known, but only through sufficient length of arc to empty the cars cleanly. This done, the weight of the empties themselves exert counter force enough to re-act upward through the same arc, where the operator throws his lever leaving the Rolls-Right fastened in position for the trips release, and the arrival of the next loads. Five cars, or 18,000 lb. of coal are thus dumped by one man in about 20 seconds. This mine produces about 2000 tons of coal per day.

**Typical Installations.**

The first was installed at the coal mine slope known as Dolomite No. 1. The coal cars, after being brought to the foot of the slope by an endless rope are attached in trips of four to a tail-rope haulage and hoisted at a speed of 1,500 ft. per minute up a double-track slope 1,900 ft. long having a maximum grade of 26¼ deg. At the top of the slope the cars enter either of two car tipples which are located over a 300-ton pyramid bin, from which the coal is loaded directly into railroad cars. The average capacity of this mine is 1,500 tons in eight hours.

At Dolomite No. 3 are located two 5 car dumps of the same kind. The cars at this mine are brought to the foot of the slope by an electric locomotive and are there made up into trips of five, which are hauled by a 700 hp. double-drum electric hoist up a 30 deg. grade 1,400 ft. long at a speed of 2,000 ft. per minute. The rotary dumps are set at an angle of 15 deg. over a 400-ton double bin with V-shaped bottom, as shown in Fig. 1.

(Continued in June)

# THE SAFETY CRUSADE

## 3891 Men—95 Days

### No Lost Time Accidents—Perfect Record Established At Joliet Works

"The month of December, 1923, marked the establishing of the first perfect score we had ever attained in our Accident Prevention Campaign. We were all very proud, and rightly so.

The month of January, 1924, followed with another perfect record. Two months in succession without a lost time accident. Indeed, every one of us on the plant had just reason for being proud of such an unusual accomplishment.

The month of February, 1924, started out in the same encouraging manner and as the month nearly passed we had hoped for another month of perfect score. However on February 23, a gripman slipped and injured his ankle thus breaking the record after 95 days with an average of 3891 men employed per day without a lost time accident.

Every one of us at Joliet Works justly feels proud of this record. We are proud of our efforts which made it possible; proud of the connection with a company which is conscientiously endeavoring to conduct a safe manufacturing establishment; and proud of this contribution we have made to the humanitarian work which is being carried on the world over.

Our slogan for 1924 is "Keep On Keeping On" and we are going to start right in and try to make another record.

This record did not just happen. It was the result of a determined and conscientious effort on the part of every man employed at this plant who really strived in making it possible.

The team work, loyalty, and service which went to make up such a fine showing as was manifested by all concerned speaks entirely for itself and entirely exemplifies the adoption of the Joliet Works' slogan in Accident Prevention for 1924 which is, "Keep On Keeping On."

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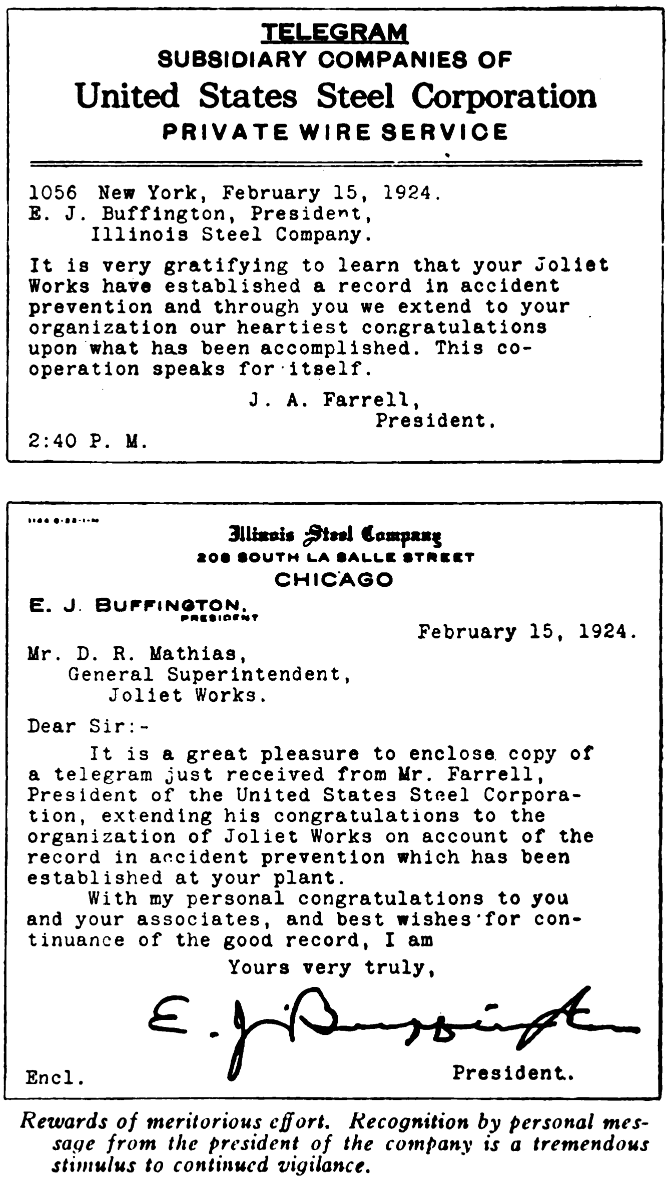
### Banquet for Safety Committeemen and Foremen

On Tuesday evening, February 12, 1924, a Safety banquet for Safety Committeemen and Foremen was held in the Auditorium of the Steel Works Club and over 400 Safety workers packed the large auditorium. In addition an invitation was sent to all of the clergy in the community and to a number of representatives of other industries in the community.

The Safety Committeemen were the guests of the management in an effort to show their appreciation of their past good work in Accident Prevention and to appeal to them for their continued co-operation and to show them that the management of this company and the management of the United States Steel Corporation was back of them in every way in their efforts in this great humanitarian work of the eliminating of preventable accidents in this industry.

The large auditorium was packed even to over its capacity and the affair was a combined Safety Meeting and to honor the birthday of Abraham Lincoln. The tables and room were fittingly decorated for both occasions and on the night of the banquet we had established a record of 85 days without a lost time accident.



TELEGRAM
SUBSIDIARY COMPANIES OF
United States Steel Corporation
PRIVATE WIRE SERVICE

1056 New York, February 15, 1924.
E. J. Buffington, President,
Illinois Steel Company.

It is very gratifying to learn that your Joliet Works have established a record in accident prevention and through you we extend to your organization our heartiest congratulations upon what has been accomplished. This co-operation speaks for itself.

J. A. Farrell,
President.

2:40 P. M.

Illinois Steel Company
208 SOUTH LA SALLE STREET
CHICAGO

E. J. BUFFINGTON,
PRESIDENT

February 15, 1924.

Mr. D. R. Mathias,
General Superintendent,
Joliet Works.

Dear Sir:-

It is a great pleasure to enclose copy of a telegram just received from Mr. Farrell, President of the United States Steel Corporation, extending his congratulations to the organization of Joliet Works on account of the record in accident prevention which has been established at your plant.

With my personal congratulations to you and your associates, and best wishes for continuance of the good record, I am

Yours very truly,

E. J. Buffington
President.

Encl.

*Rewards of meritorious effort. Recognition by personal message from the president of the company is a tremendous stimulus to continued vigilance.*

Mr. D. R. Mathias, General Superintendent, acted as toastmaster and after the invocation had been pro-

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nounced by Rev. Father Albert S. Olszewski, of the Holy Cross Church, a flash light picture of the assemblage was taken and a reproduction of the same appears at the bottom of this page.

After Mr. Mathias had made the opening announcement and stated the purpose of the meeting, Mr. R. W. Campbell, who is General Attorney for the company and also chairman of the General Safety Committee, made a very fitting address which might well be termed, "Reminiscences". Mr. Campbell gave a review of the early days in Accident Prevention and mentioned the part that Joliet Works played in this effort and also mentioned that organized accident prevention work had its inception at Joliet Works and that Mr. H. B. Smith who devoted his entire lifetime to the safety cause, was the first safety inspector in this country and

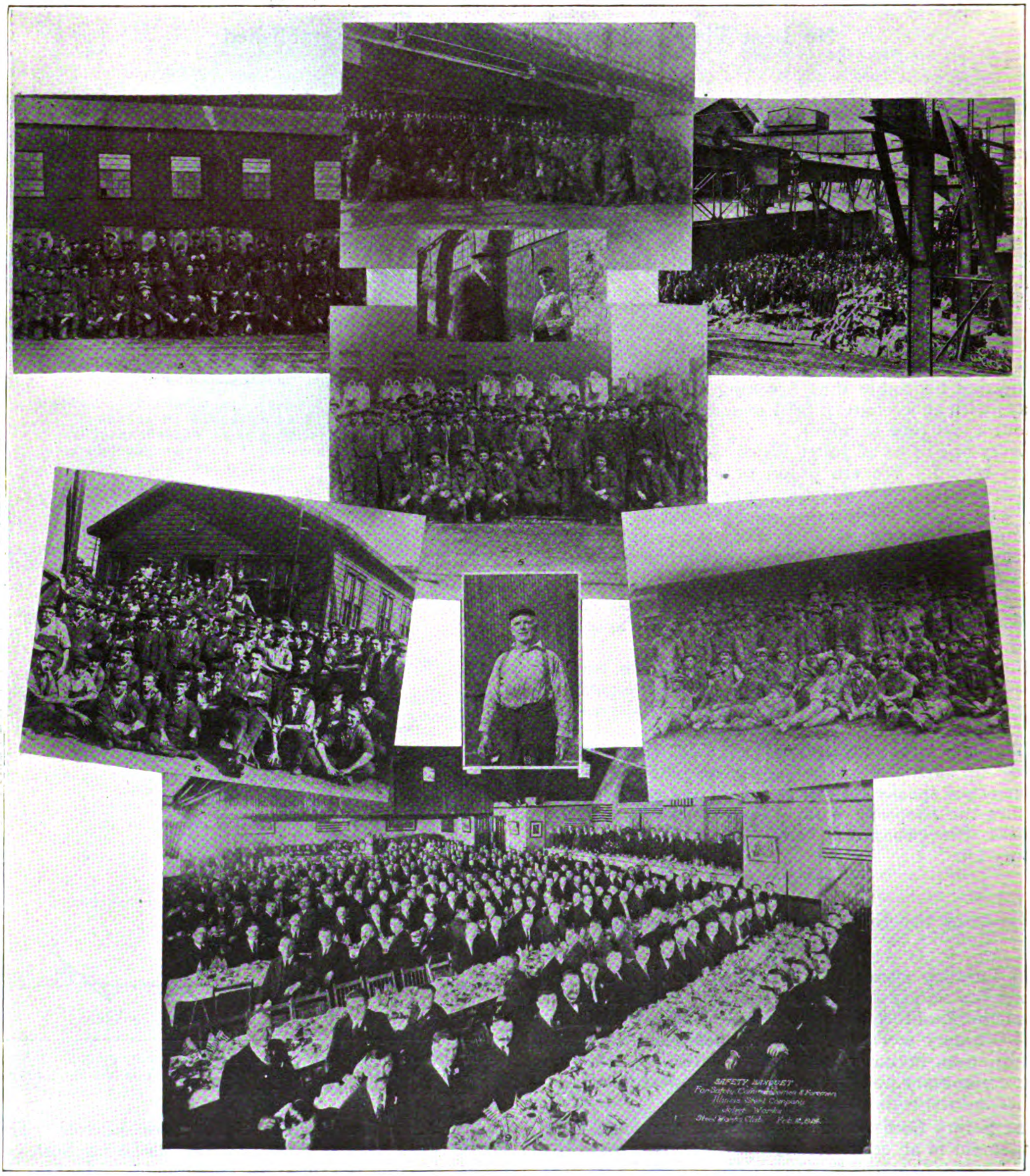

FIG. 1—*Splice mill safety meeting.* FIG. 2—*John Woods, right; John P. Eib, left.* FIG. 3—*Billet mill safety meeting.* FIG. 4—*Mechanical department safety meeting.* FIG. 5—*Converting department safety meeting.* FIG. 6—*Bolt and nut factory safety meeting.* FIG. 7—*Mason department safety meeting.* FIG. 8—*John Woods.* FIG. 9—*Safety banquet at Steel Works Club.*

probably in the world, having been appointed safety inspector at Joliet Works in 1893.

Mr. R. J. Young, manager of the Department of Safety and Relief, and secretary of the Central Safety Committee of the Illinois Steel Company, also gave a very interesting review of the early days as well as the present day work in this great field. Mr. Young stated that he had recently returned from New York where a meeting of the Committee of Safety of the United States Steel Corporation had just been held and he brought a direct message from Judge Gary, who is the executive head of the United States Steel Corporation, to the Committeemen and Safety workers at Joliet, which message was received with great appreciation and gratification.

Rev. Walter Macpherson of the Universalist Church of Joliet, then gave one of his wonderful talks for which he is renowned and his combined talk about the great Emancipator and the Safety work, coupled with his keen wit and humor, of which he is so entirely capable, pleased the entire assemblage and was received with such enthusiasm that everyone present wanted him to continue much longer than he really did.

The closing number of the program consisted of a moving picture film entitled, "The House that Jack Built," the scenario of which was written by Mr. Marcus A. Dow, formerly General Safety Agent of the New York Central lines, and contained a beautiful representation of safety not only on the job but carrying it into the home life as well. Beyond a doubt this is one of the greatest, if not the greatest, safety films which has ever been produced.

The entire meeting was one of enthusiasm and was very well received and it is felt that a great deal of good will result from this Get-Together meeting. We wish that it were possible for us to shake the hand and personally thank each safety committeeman and foreman and worker of this plant who has helped to make our record possible but inasmuch as this could not be accomplished we wish to take this means of again thanking each and everyone of you for the part played in accomplishing this feat and to sincerely ask your continued co-operation.

## International First Aid Contest

Several thousand invitations to attend and participate in the Fourth International First-Aid and Mine-Rescue Contest, to be held at Huntington, West Virginia, September 11, 12, and 13, have been sent out by the Department of the Interior. The invitations are being mailed to the coal and metal mining companies of the country, quarry operators, metallurgical plants, local unions of the United Mine Workers of America, petroleum refiners, the larger oil-producing companies, pipe line operators, the mine inspectors of the various states, and to the mining officials of various foreign countries, including England, Canada, Mexico, France, and Belgium. Metal mining companies operating in Mexico, and the larger coal mining companies of England and Canada, are also being invited to attend the contest.

The International First-Aid and Mine-Rescue Contest will be held under the auspices of the Bureau of Mines, with the co-operation of the West Virginia Department of Mines, the Huntington Chamber of Commerce, the American National Red Cross, the National Safety Council, and various mine operators associations and miners' organizations. It is anticipated that as many as 80 teams of trained miners will compete for the various prizes offered for proficiency in first-aid and mine-rescue methods.

The Department calls attention to the fact that more than 115,000 miners have already been trained in first-aid to the injured and mine-rescue methods by the Bureau of Mines. This event promises, it is stated to be an important one for the promotion of safety and efficiency in mining. A large attendance of miners is expected at the contest, and it is anticipated that many prominent representatives of the industry who have taken a keen interest in the promotion of industrial safety will be present.

The first-aid and mine-rescue contests will be for the international championships. International contest cups, medals, and prizes will also be awared. The judging of the events will be according to Bureau of Mines standards by judges thoroughly familiar with first-aid and mine-rescue work. Entries for competing teams will close on August 27.

A feature of the meet will be the awarding of the congressional medal which is given annually to the team of miners adjudged to be most thoroughly skilled in first-aid and mine-rescue methods. Another interesting feature will be the awarding of the medals offered annually by the Joseph A. Holmes Safety Association in commemoration of notable deeds of heroism performed by miners in succoring their comrades imperiled at mine fires and disasters. The selection of the individual miners to receive these medals was made by the directors of the Joseph A. Holmes Safety Association last month.

## Industrial Accidents Up 20 Per Cent

A 20 per cent increase in industrial accidents in the United States in 1923 is estimated by the National Safety Council from statistics collected from states, insurance agencies and industrial concerns. The total for the year is estimated at 3,000,000 accidents, of which 23,000 were fatal and 115,000 caused permanent disability.

Industrial accidents reported by Illinois, Indiana, Wisconsin, Massachusetts, New Jersey, Delaware, Washington, Oregon and Pennsylvania, totalled more than 500,000. Pennsylvania reported 105,473 accidents, 2,412 of which were fatal; Massachusetts, 64,890 with 33 fatal; Oregon, 30,227, and 178 fatal; New Jersey, 49,392, of which 390 fatal; Wisconsin, 20,095 total, 154 fatal; Delaware, 14 fatal; Illinois, 55,142 total; Washington, 34,745, with 366 fatalities; Indiana, 54,860, and 268 fatal.

Increased production, many new employes, and a let down in safety interest by employers and employes are held as factors. Many steel plants, public utilities, mines, railroads, automobile and general manufacturing concerns made excellent records.

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In addition to the contract recently awarded the U. G. I. Contracting Company, of Philadelphia, by the Enterprise Gas Company, of Egg Harbor City, N. J., for new gas making and boiler equipment, the former company has been awarded an additional contract covering all foundations, new buildings and every other improvement required at the plant and made necessary by the installation of the new manufacturing units.

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# Experiences With Multiple Feed, High Pressure Lubrication[†]

By LOUIS R. HUMPTON[*]

IT is a matter of constant surprise to me that in so many manufacturing plants and steel mills so little attention is given to the solution of problems connected with lubrication. In a large number of cases the same methods are in use today as were followed 50 years ago. Although new methods of improved lubrication have been brought forward, perfected, and although these have been successful in eliminating accidents and adding plant efficiency wherever used, it is a shocking fact that in so many big establishments the old fashioned, antiquated oil can is still the mainstay of lubrication. The only explanation of this condition is the existence of the "if it was good enough for father it's good enough for me" spirit. And this despite the large number of mishaps to men engaged in oiling by the old fashioned methods and the number of fires, some of them quite costly, which result from the spattering of lubricants.

Considering the matter merely from the standpoint of accidents to oilers, statistics tell an impressive story. Companies writing compensation insurance in Pennsylvania, covering all kinds of industries over a period of years, have compiled figures showing that out of 1,542,349 compensation days lost as a result of accident, 104,971—or nearly 7 per cent—were due to injuries to workmen while oiling or cleaning machinery.

"Safety First" signs were probably displayed in all of the plants where these accidents occurred, but machinery made safe—and it can be made safe—is a great deal better than "Safety First" signs.

Now from the standpoint of efficiency. Have you ever considered how many bearing caps you find which have drilled with a one-eighth of an inch oil hole? It is expected that enough oil can be squirted into this hole to lubricate the bearing perfectly—and possible the expectation could be fulfilled if the oiler or machine operator was able to force a stream of oil from ¼ to ¾ of an inch in diameter into this ⅛-in. oil hole. But it can't be done. The oiler wastes a good deal of time trying, but he never becomes proficient at an impossible job.

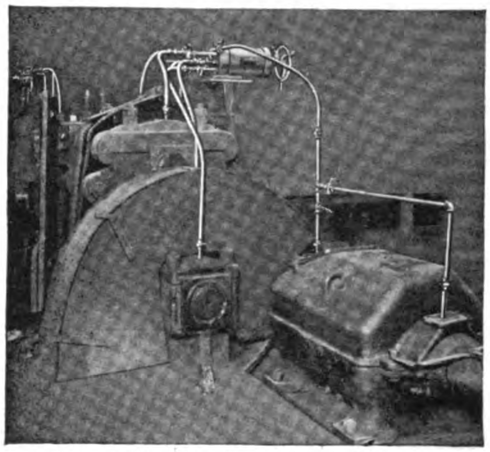
I have often wondered—to point to another phase of the question—whether it would not be profitable to drill oil wells around the machine foundations in some of our large mills, so much oil is spilled and wasted in plants where the antiquated methods still prevail. And with this spillage, and with oil lying around on the floor in puddles, the menace of fire is apparent. Many a blaze is directly traceable to this cause. In my own plant we have had two very bad fires—under the old conditions—caused by sparks igniting oil which had collected on the floor. Two 200-hp. motors were destroyed by the fires.

We have been all through the question of lubrication in my plant, making progress slowly, but at any rate constantly experimenting and trying to improve. We think we have solved our problem pretty completely now.

Take for example, our cold scarfing machine for scarving bevel edge on plate or skelp iron for making lap weld boiler tubes. This machine is driven with a 50-hp. motor and is subject to very hard service at all times. It has 12 bearings. Formerly we used machinery oil to lubricate it, with oil rings to carry the oil around the shaft.

But we were constantly having trouble, necessitating frequent shut-downs for repairs. Because of cold weather, because of dirt getting into bearings, the rings would not follow around the shaft. Consequently the bearings would run hot.

Then we tried sight feed oil cups, but they would not stand the vibration. The thread on the stem would become worn, and shut off tight. The bearings would start to heat. As we could not get at the bearings while the machine was running, it would become necessary to stop the machine. The delays due to complete stoppage were frequent. Another trouble with the oil cups was that the stems would become loose, work out and run oil cup dry. We tried ordinary grease cups, but there was danger in getting at them and we could refill them only when the machine was standing still. They were an improvement over the oil cups, it must be confessed, but they were not entirely satisfactory.



*Lap weld finishing mill, and 24 h.p. Westinghouse motor lubricated by one Keystone Manifold Safety Lubricator.*

Finally we tried a manifold safety lubricator, connecting it to each bearing, using half-inch standard gas pipe. With that we ran the machine continuously for six months without any delay or trouble of any kind. Not only were we saved the loss of time incident to shutting off operations, but we made a considerable monetary saving. Formerly, we had used one barrel of oil each week, at a cost of $15, but with the manifold safety lubricator we cut the oil consumption down to the point where the grease itself cost us only $8 per month—as against $60 previously with oil. Our babbitt metal bills have been cut 75 per cent. And as I have indicated before, we eliminated all fire

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[*] Chief Electrical Engineer of Parkesburg Iron Company.

[†] Copyright A. I. & S. E. E.

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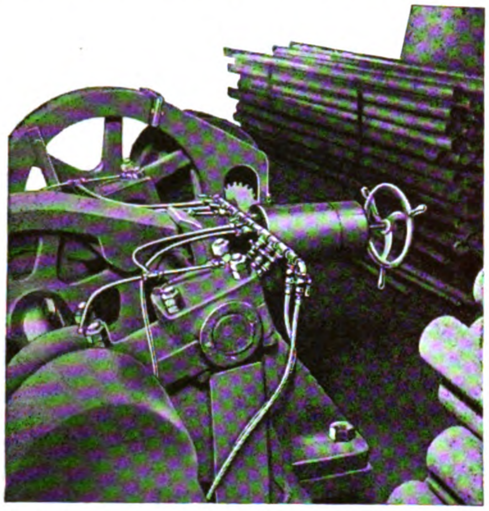
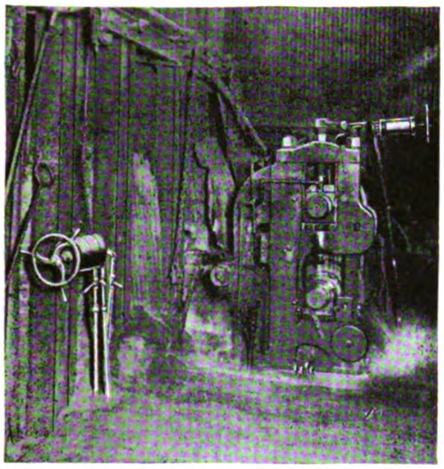
risk. Since we installed the first lubricator on this machine, we have placed 40 more of them throughout the plant. We are now operating virtually without loss of time so far as bearing trouble is concerned.

In addition we have this type of lubricator connected with Westinghouse mill type motors. In the old days we had constant trouble because of oil splashing out of oil well bearings and saturating the armature coils and field coils, causing a short circuit, and necessitating rewinding of armature and coils. But with our new-style lubricator all these difficulties have been done away with. Another place where we have solved a problem is with our scrap or alligator shears. Formerly the men poured oil all over the outside of the bearings, but very little reached the right place. Now the lubricator takes care of this, distributing grease to the parts that need lubrication most.



*Lubricator installed on tube straightening machine feeding all seventeen bearings.*



200-*h.p., lap-welding mill equipped with lubricator. Pipes from lubricator lead down under floor, and come up under roll housing connecting with brasses.*

Many of us make the mistake of worrying too much about initial cost in considering new equipment of this sort. I suppose at our plant we are no different than others in such matters and that we did a large amount of hesitating before we decided to go ahead with this lubricating proposition. But I have just looked up the figures and in the light of our experience I feel that we made a cheap investment.

Take the 8-lb. manifold safety lubricator installation on our 10-ton, 85-ft. span crane, for example. The lubricator itself cost $60, although the price may be somewhat higher now than it was two years ago, when the installation was made. The equipment consisted, first, of 100 feet of 1½-in. pipe run the length of the bridge and across its ends. This pipe cost 21 cents a foot or $21, the biggest item of the equipment cost; it has 18 outlets reduced from 1½ in. to ½ in.

In addition there were 18 stopcocks at 70 cents each, 18 tees 1½x1½x½ in. at 17 cents each, 300 ft. of ½ in. black pipe at 11 cents a foot and 36 unions ½ in. size at 15 cents each—a total for equipment of $45.36.

Lubrication equipment for the trolley of the crane was provided by running lines separately to 16 bearings. For this it was necessary to use 120 ft. of ½-in. pipe at 11 cents per foot, 16 stopcocks at 70 cents each, 16 unions at 15 cents each—a total of $26.80.

The actual task of installing the lubricator and its equipment required the services of four men receiving 66 cents an hour for a trifle less than two full days. The charge for labor was entered as $42.24. The total cost of lubrication, equipment and installation on both crane and trolley was $174.40.

Obviously we no longer have accidents from lubricating. There is one central point of lubricant distribution, with many bearings lubricated from one central point. Pipe lines lead from the manifolds to each bearing and the lubricating grease is forced into each bearing under high pressure. Many of the bearings lubricated under this system are as much as 100 feet away from the point of distribution, but nevertheless the results are perfect. The lubricator and the manifolds are at all times stationed in a safe place, so that our employes never need take chances on their safety. We have no accidents.

Iron pipe, brass tubing and armored flexible metallic tubing runs from the lubricator to the bearings, and when the very best petroleum grease is used there is no possible chance of the pipe lines becoming stopped up, because in high grade grease there is no filler present to become separated from the oil.

All of us feel now that our worries in regard to lubrication are over.

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Employees of the General Electric Company are owners of, or are paying on the installment plan for, a total of $11,458,260 in G-E Employee's Securities Corporation bonds. This was announced after a tabulation had been made of the subscriptions to the third offering of these bonds, these subscriptions amounting to $5,339,800.

The total bonds subscribed for in all three offerings, in the various factories of the company, are as follows: Schenectady, $3,584,010; West Lynn, $373,570; River Works, Lynn, $1,196,400; Pittsfield, $737,570; Erie, $833,770; Fort Wayne, $742,150; Edison Lamp Works, $617,140; National Lamp Works, $1,003,310; all other factories, $581,790; general office, $986,120; district offices, $802,430.

The number of the company's employees who have subscribed to these bonds, which pay 8 per cent as long as the individual remains with the General Electric, is around 267,100.

# SHEET AND TIN PLATE

## *Rotary Flying Shears*

SOME time ago Mr. Norman Rendleman conceived the idea of shearing round, flat and square bars "on the fly" immediately behind the finishing stand of a rolling mill by means of two rotary knives set at an angle to the line of travel of the bar. This meant taking a rotary shear and placing it at an angle with the line of travel of the bar leaving the mill, and then slipping the bar between the knives. Suitable speed of rotation of the rotary cutters, combined with the angle at which they were set, would enable the shear to cut the bar without interrupting its delivery from the mill.

In mills which roll steel of small sizes such as rounds and squares, the lengths of bars which the hot bed will take nearly always determines the size of billets which can be used.

For instance, if a mill rolling half-inch rounds is equipped with a hot bed 200 ft. long, the weight of the billet which can be rolled will be 200×.668 lbs. = 134 lbs. If this billet is four inches square, then the length of the billet will be 29 in. This is a very short and light billet. It is much more convenient and economical to work a 400-lb. billet. This weight of billet, however, will finish into a half-inch round 600 ft. long, which is altogether too much for a hot bed 200 ft. long.

A Rotary Flying Shear located immediately behind the finishing stand of the mill will automatically cut this bar into lengths of 200 ft. as it comes from the mill without interrupting its forward motion.

The equipment consists of the shear proper arranged in connection with a runout table with driven rollers; a flag arranged to be set at various positions on the runout table, which is operated by the front end of the bar, and a kickoff to push the bars from the runout table to the hot bed.

The shear consists of two circular cutters mounted on a suitable base and rotated at the proper speed by two adjustable speed motors each connected to the spindle of one of the cutters. Another motor raises and lowers the upper spidle. The shear is arranged with the cutters at an angle of about 45 deg. to the line of travel of the bar leaving the mill.

The bar from the mill runs past the shear knives and along the runout table until it hits the flag. When the flag moves it releases the forward end of the swinging trough on the shear, which "flips" the bar between the knives. See illustrations.

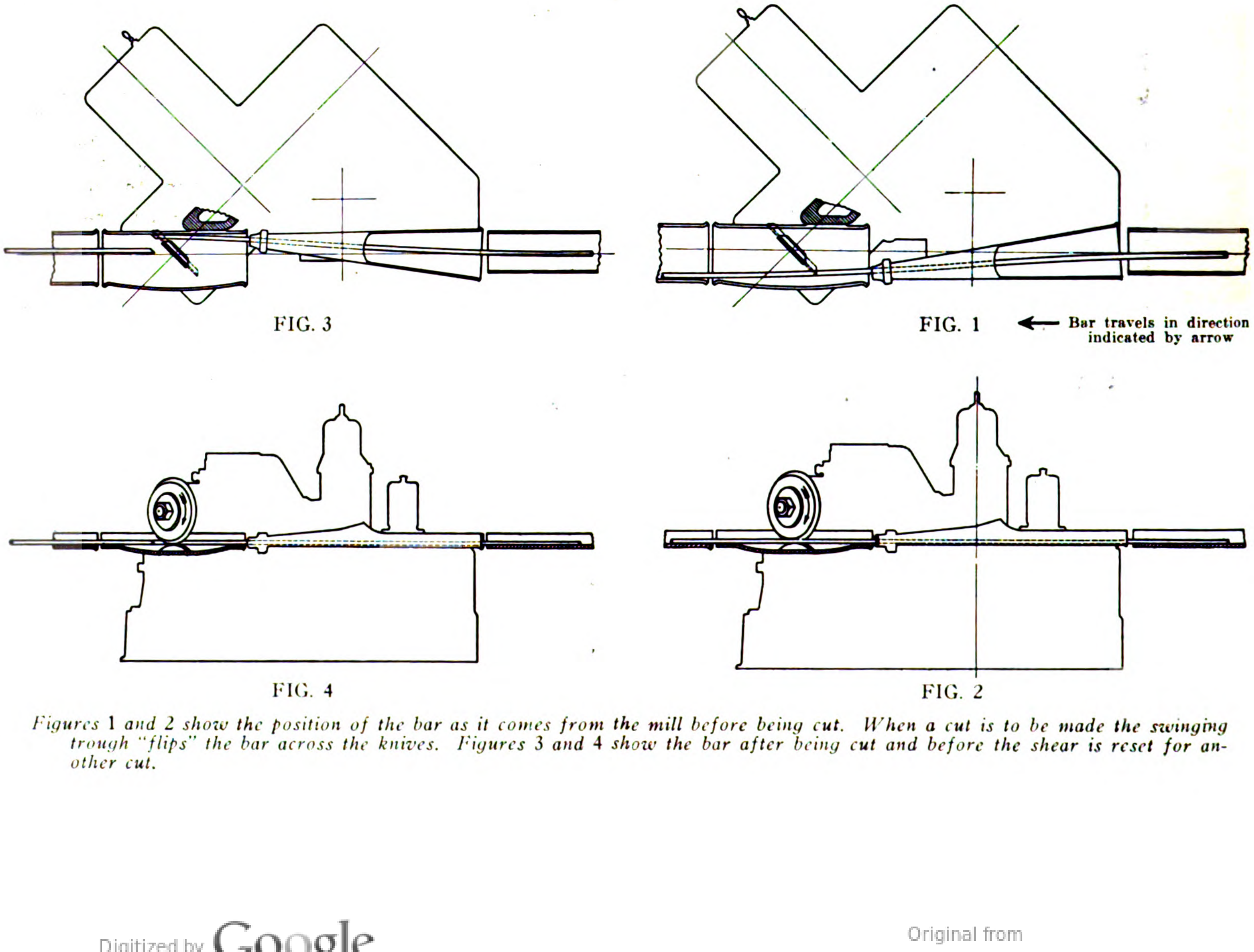

FIG. 3

FIG. 1 ← Bar travels in direction indicated by arrow

FIG. 4

FIG. 2

*Figures 1 and 2 show the position of the bar as it comes from the mill before being cut. When a cut is to be made the swinging trough "flips" the bar across the knives. Figures 3 and 4 show the bar after being cut and before the shear is reset for another cut.*

# Selecting Material For Drawn Parts*

## A Suggested Method of Testing Sheets and Strips to Show Their Suitability for Forming and Drawing Operations—All Shipments Should Be Carefully Sampled

**By L. N. BROWN†**

THE use of sheet and strip metal has increased rapidly during the last few years and manufacturers have been called upon for an ever-increasing tonnage, better drawing quality, and better surface. The automobile industry is probably the most insistent in striving for a better product and a desire to reduce costs. Confronted by these demands, the mills have directed their efforts toward the delivery of material. Their personnel has been occupied largely with the problems incident to production, as any increase forced the use of new sources of raw material with their problems. These problems, combined with those met in the daily routine, have demanded immediate attention, with the result that the standardizing of heat treatments, quality, or temper, etc., have been neglected.

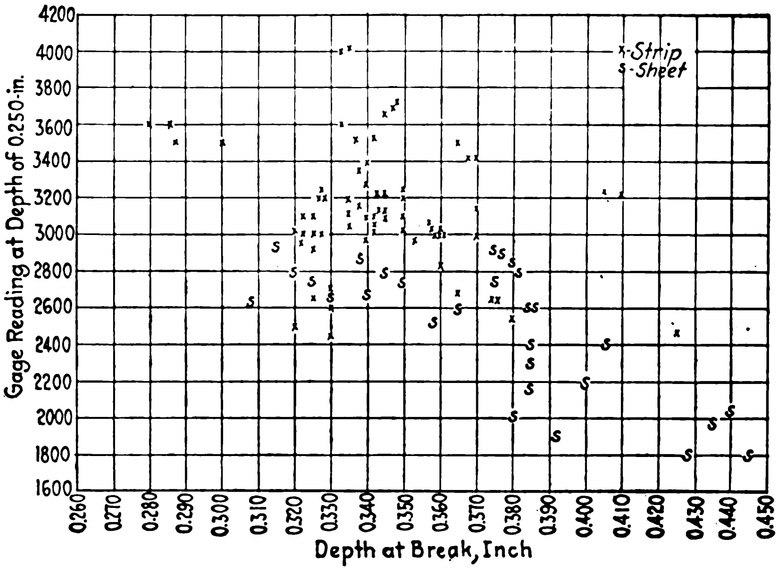

FIG. 1—Results of tests of 20-gage material received, for one part, during the year.

Considerable work in standardizing has been done by many companies, but no acceptable method has been developed. The following method, therefore, is given with the hope that some method that can be accepted by the manufacturers and users may be developed. The problem of selecting a material with such properties that the losses in processing are a minimum is interesting and difficult. A description of the properties required is likewise difficult, largely because of loose terms. Another handicap is the number of methods of testing which have not been standardized and concerning which little information is available.

In the selection of drawing or forming stock, it is advisable to eliminate as many variables as possible; consequently the method of testing the material is of the utmost importance. The method should be rapid and comparatively easy of application, as it is more important that a large percentage of the stock be tested by a more accurate method. It is necessary to consider the process by which the material is made and samples must be selected with care and must be representative, as there is liable to be a great variation in any shipment. The results of the tests of material received during one year for one part are shown, graphically, in Fig. 1. A print of the part to be made was sent with the purchase orders in each case.

Some plants have found it advantageous to use one class of material and, by processing, have been able to produce certain results. Another plant may work on less expensive material but produce the same result by varying the method of handling. A third plant may use more expensive material than either and produce comparable results with less hand work. The equipment, space, and facilities for handling are important factors and the ultimate choice may be governed by any one of about a dozen elements.

The method here described shows one plan of attack that has been satisfactory in so far as it gives a quick, fairly accurate check. The manipulation is simple, the first cost low, and the upkeep not excessive. The testing requires no special training, and after standards are set may be performed by any one. The machine used is the Olsen ductility machine with pressure-gage attachment. In principle, a plunger is pressed into the stock, which is held between two dies. The depth of impression is shown by a dial micrometer and the pressure exerted is indicated by a pressure gage. The apparatus is subject to some criticism but seemed to offer the best possibilities at the time the work was started.

Inasmuch as that property vaguely called "hardness" is indicative, in a general way, of certain physical properties, it was thought that if a method for measuring the hardness with this machine could be devised, it would aid greatly in solving the problem. A large number of tests were made and, from the results, charts were developed that seemed to show a marked relation between the results obtained with the standard hardness testing machines and the results obtained by the method described later.

On 16-gage material and under (where the ⅞-in. ball is used) the machine seemed to have considerable advantage for obvious reasons. The method of operation is a slight modification of one used by several firms that have done considerable testing with this machine. It consists of taking for a "hardness factor" the number of pounds per 0.001 in. at a depth of 0.250 in. This is obtained by dividing the reading on the pressure gage at a depth of 0.250 in. by the

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*Paper presented at the Canadian Meeting, August, 1923, American Institute of Mining and Metallurgical Engineers.

†Inspection Division, Maxwell Motor Corporation.

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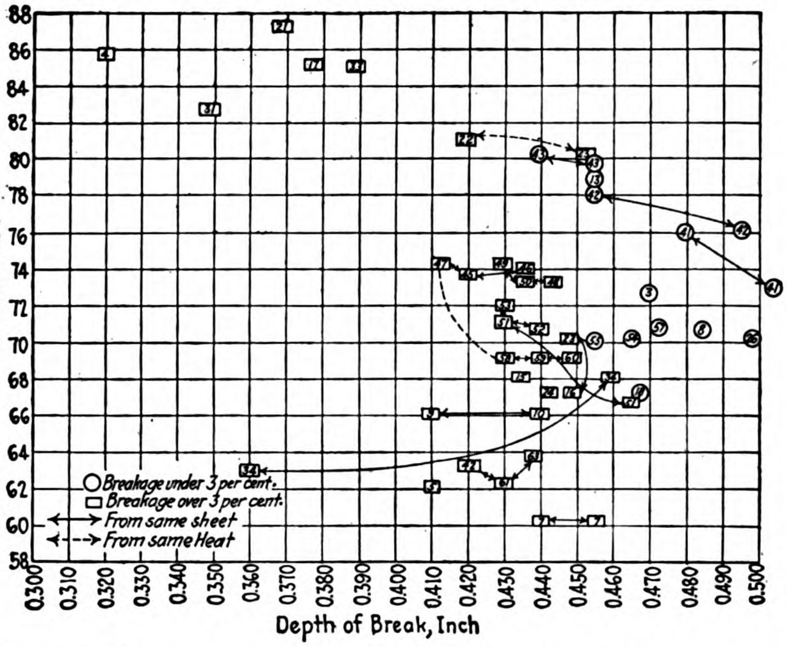

**FIG. 2—Results of tests of 16-gage, blue-annealed and box-annealed material received, for two parts, during one year.**

thickness of the stock, in thousandths of an inch. One of the reasons for using this figure instead of the direct reading obtained is that a correction is necessary for variation in gage in order that results may be comparable. To get complete data, pressure readings were taken and recorded at 0.300 in., 0.350 in., 0.400 in. etc., as well as the depth and pressure reading at the point of rupture. The hardness factor and "depth" at rupture will be discussed later.

The suitability of a material usually depends on: (1) Percentage of breakage on drawn jobs or defectives on former jobs; (2) freedom from graining or roughness; (3) freedom from cross wrinkles, stretcher strains, etc.; (4) variation in gage. The surface finish must be considered to a certain degree. The result desired is a finished piece free from breaks and objectionable surface defects caused by processing. With so-called hot-rolled or blue-annealed material, the breakage and gage variations are the important requisites, the others becoming important as material of higher finish is used.

To simplify the problem somewhat, the discussion will be limited to blue-annealed material, or stock of that character where the finish is comparatively unimportant. Just as the hardness values are indicative, to a considerable degree, of the other physical properties of heat-treated stock, the hardness factor is an indication of the other physical properties of the material under discussion. A percentage hardness inspection, small or total, presupposes many things such as correct analysis, homogenity, uniformity of handling, etc. Hardness is probably the best practical index we have, at present, when the history of the part in question is known — analysis, heat treatment, etc. As the history of this class of material is somewhat shrouded, the test must be carried to destruction after the hardness factor is derived, in order to obtain necessary information regarding workability.

The results of the tests of extra deep drawing material received during a year for two rather difficult parts are shown in Fig. 2. The numbers given are the numbers of the test pieces. Circles around a number indicate that the total breakage on the lot represented by that test piece was less than 3 per cent; the numbers are placed inside rectangles when the loss is over 3 per cent. Lines connecting two numbers indicate that both samples are from the same sheet or strip. For example, the two tests marked "34" were from the same test piece and, in this case, were taken within 10 in. of each other; the breakage was 100 per cent on a small lot. Tests 58, 59 and 60 were strips from a sheet of the same heat number as tests 45, 46, and 47, which were samples from a different sheet. These show uneven annealing. On the run of this lot of over 5,000 pieces, the breakage was about 18 per cent. The breakage on the lot represented by tests 48, 49, and 50 was 4.6 per cent on a run of 1100; this lot was bought in an emergency as deep drawing only.

The reason so many bad samples are shown on the chart is that we were attempting to establish limits and carefully investigated all excessive breakage. The good samples represent a much greater tonnage. The limits necessary are easily discernible.

One of the peculiarities of certain grades of full finished stock is its tendency to "roughen" or "grain" when subjected to a comparatively deep draw. This is a bad condition as it necessitates a snagging, or polishing, operation. Dies are not designed to draw equally all over and the contrast of "rough" and "smooth" areas is very noticeable after japanning. It was found desirable to determine, roughly, if any

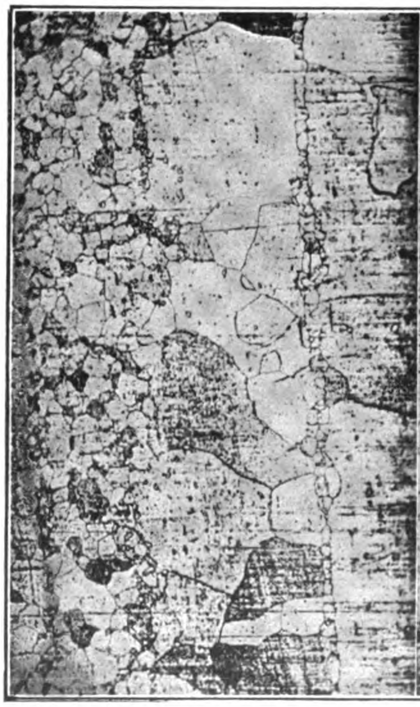

**FIG. 3—Test strip No. 34A. × 100.**

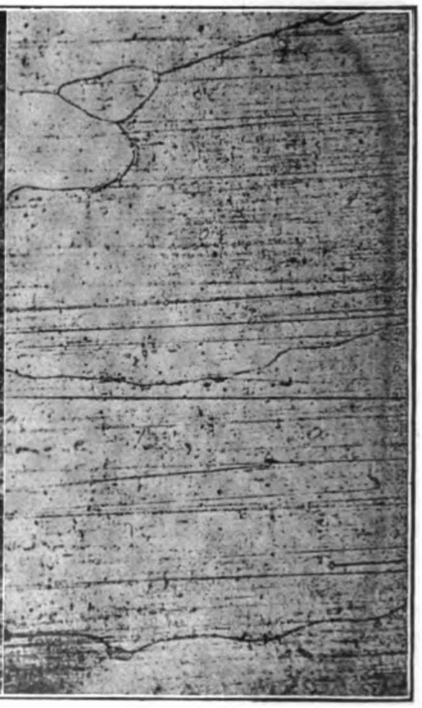

**FIG. 4—Test strip No. 34B. × 100.**

depth of impression on the testing machine was comparable to the maximum effect of the presses under regular operation. Long strips were cut from one side of a sheet and impressions made with the testing machine at depths of 0.100, 0.125, 0.150 in., etc. A part was then drawn from the other half of the sheet. The character of the surface of the stamping at its roughest area was compared with the various impressions and the one determined whose surface was most nearly like it. This was repeated with several kinds of material. It could then be quite definitely stated that to be satisfactory a material should not roughen on test at a depth of, say, 0.050 in. greater than the depth selected, this giving a good factor of safety.

The phenomena known as stretcher strains, wrinkles, etc., can usually be discounted by observing the hardness factor carefully in connection with the total depth.

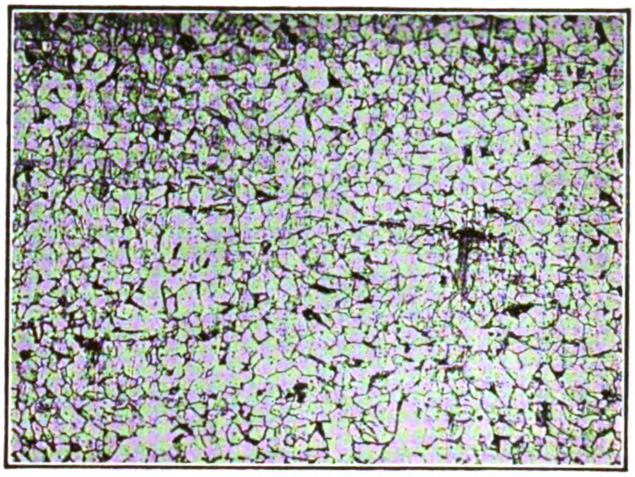

FIG. 7—Test strip No. 48, special deep drawing stock. × 100.

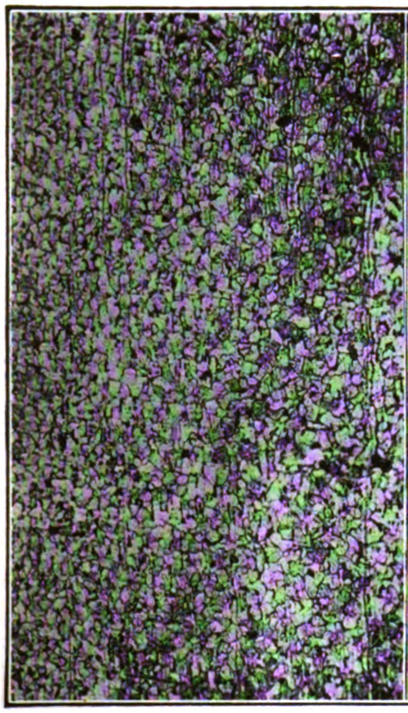

FIG. 5—Test strip No. 61, 16-gage material. × 100.

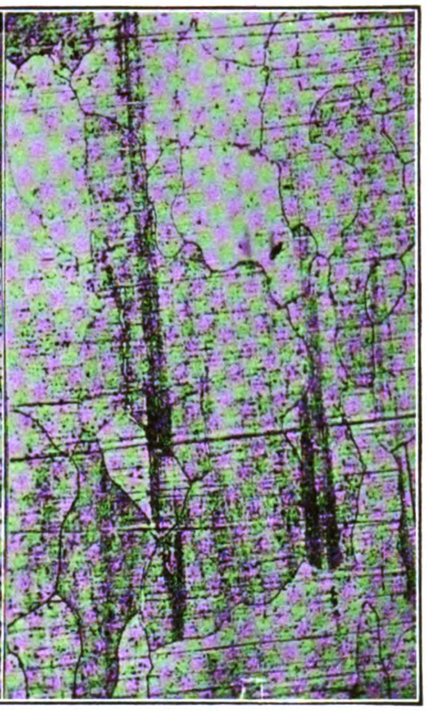

FIG. 6—Test strip No. 5, 16-gage material. × 100.

The permissible variation in gage has been worked out by many concerns using this material, but will not be discussed here.

At present, the best material is thought to be that which makes the best looking part and which requires the least hand work to finish. It is, therefore, frequently advisable to select material of slightly inferior finish but which will draw better than material with a higher finish. It is possible, however, to get both surface and temper for drawing or for forming.

By making a number of tests on the machine with carefully selected samples, parts of the same sheet or strip being run on the presses at a time when there is no breakage, and closely observing the finished part, limits can be established. These limits are comparable with the customary manner of setting those with a Brinell or Shore machine on heat-treated material. By this, we mean that by testing the material which works satisfactorily and that which does not work, we can decide the workability of a lot very closely without trying on the press. It is more difficult than setting limits with a Brinell machine at the present time as the factor of safety is not considered.

For testing material over 16 gage, the ½-in. ball and corresponding die should be used and the reading taken at a depth of 0.150 in. As the capacity of the machine is limited, the greatest part of the material causing trouble may be eliminated by using the hardness factor alone. In order to determine as definitely as is needed in the case of materials to be subjected to difficult draws, a punch and die arrangement may be installed on a tensile machine to run the test piece to rupture and the limits set accordingly, the procedure being the same as described above.

The effect of grain size will not be discussed, although it has a great influence on the character of the manufactured prod-

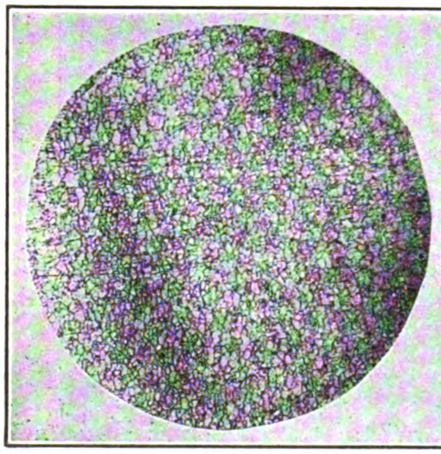

FIG. 8—Test strip No. 275, 20-gage material. × 100.

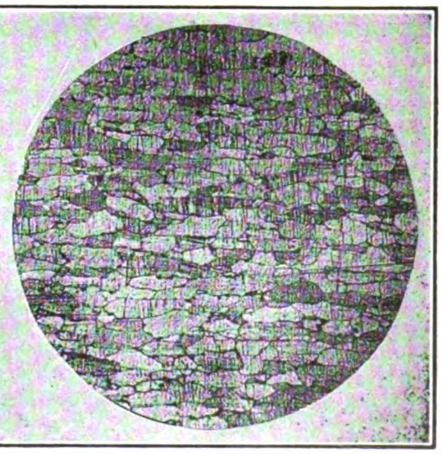

FIG. 9—Test strip No. 163, which roughened on draw. × 100.

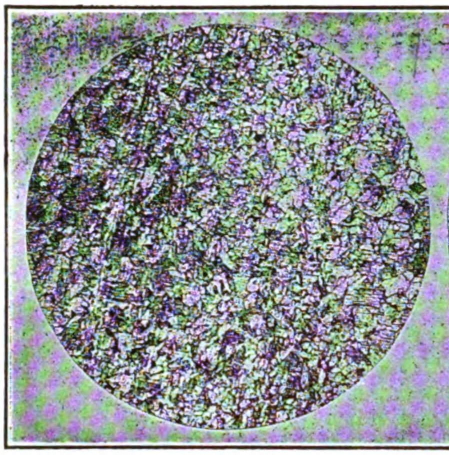

FIG. 10—Test strip No.160. × 100.

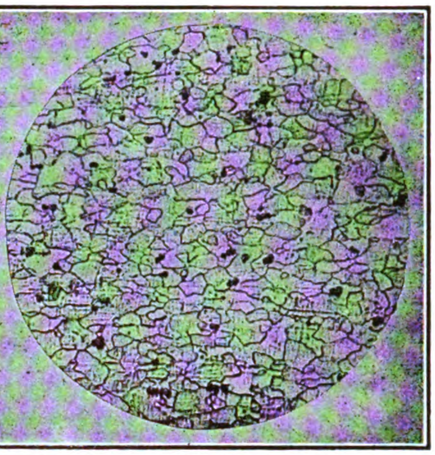

FIG. 11—Test strip No. 220. × 100.

uct. To get good results with microscopic analysis alone, expensive equipment is necessary, together with experienced operators and good supervision. As a method of checking other results, it is probably unequalled. The photomicrographs, Figs. 3 and 4, explain the cause of the peculiar results shown in Fig. 2. It is much more difficult to explain the failure of test piece No. 61 from the photomicrograph alone, Fig. 5. It is easy to explain the breakage of the parts made from Fig. 6, which is also 16 gage, but somewhat more difficult to account for test piece No. 48, Fig. 7. It is likewise difficult to explain a breakage of over 80 per cent on test piece No. 275 from the photomicrograph alone; this latter was 20-gage material.

The reason No. 163 roughened more than test piece No. 160 on the draw for the same job may easily be accounted for from Figs. 9 and 10. Nos. 220, 237, and 222, Figs. 11, 12, and 13, were for another job, one being rough, one good, and one breaking. However, it appears from testing light-gage material that the greater field for the use of the microscope is with the producers.

It is as essential that heavy-gage material be run to destruction as it is that light gage should be, if no other inspection methods are employed; Figs. 14, 15, and 16 show what may be expected. Material No. 181 worked satisfactorily with no breakage while the breakage was very high with the other two stocks.

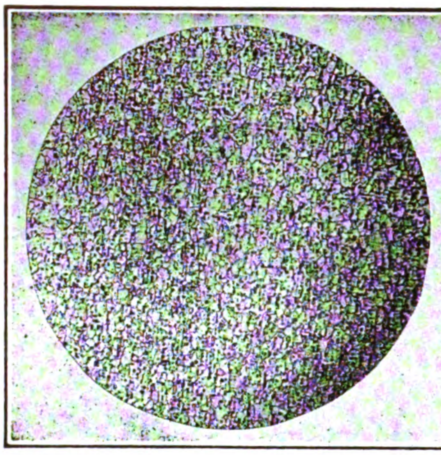

FIG. 12—Test strip No. 237. × 100.

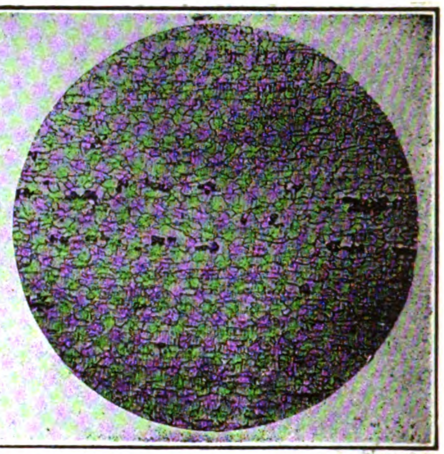

FIG. 13—Test strip No. 222. × 100.

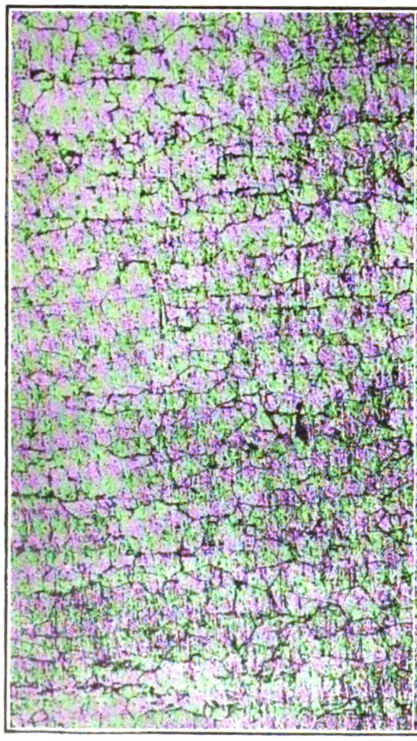

FIG. 14—Test strip No. 181. × 100.

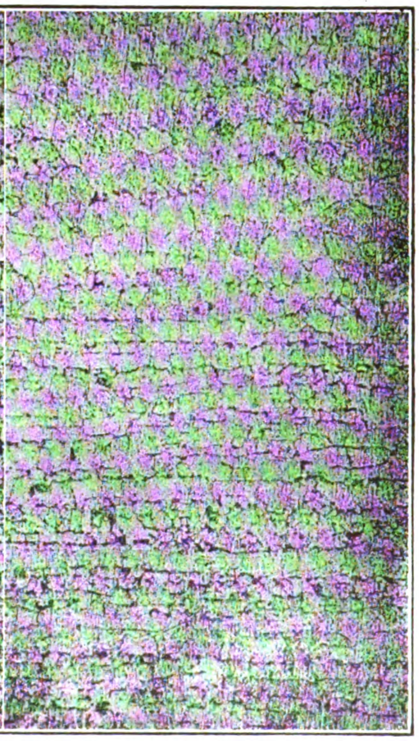

FIG. 15—Test strip No. 159. × 100.

We have endeavored to explain the method we have found the most satisfactory; that is, for light-gage material a combination of hardness tests and determining the depth at rupture. For heavy-gage, hardness tests and either testing to destruction with a heavy-type machine or examination of structure with microscope. The information as to the limits found necessary is to be furnished to the source of the material with the request that such material for those jobs be shipped as will work satisfactorily.

## Demonstrates Magnetic Testing Equipment

The Burrows Magnetic Equipment Corporation recently gave a demonstration of its magnetic testing equipment at its laboratory, 154 Ogden avenue, Jersey City, New Jersey. The use of this equipment, designed by Dr. Charles W. Burrows, formerly with the United States Bureau of Standards, has attracted considerable attention.

# CURRENT REVIEW

## A. S. M. E. Technical Program for Cleveland Spring Meeting

The Cleveland committee is planning to entertain the largest attendance at any spring meeting of the Society. Cleveland, with its wealth of industrial activity, will provide an interesting setting for the semi-annual meeting of the Society which will be held May 26 through 29, 1924. Members are urged to decide about attending the spring meeting at the earliest possible moment and send in their hotel reservations at an early date so that their reservations will be properly taken care of.

Plans for the evening sessions and entertainments have not as yet been completed. The program for these events call for two meetings of great general interest, with outstanding speakers of international fame.

The technical program for the meeting has a number of outstanding features. W. L. R. Emmet will make his first formal presentation of his development of the mercury vapor process. There will be a joint session with the American Society for Testing Materials on the Properties of Materials at High and Low Temperatures. This is of great importance at the present time because of the trend toward higher temperatures in steam power plant practice and in the oil refinery. There will be a joint session with the American Society of Refrigerating Engineers, as this body meets in Cleveland from May 27 through 29. The Machine Shop Practice Division is holding two sessions, at one of which A. L. DeLeeuw will present a paper giving the Analysis of a Machine Shop Problem on a Quantity and Final Economy Basis. The Management Division will continue the discussion on the Measurement of Management which was instituted by the presentation of the paper by Prof. Joseph W. Roe on Methods of Management during Management Week in October, 1923.

**Technical Program:**

Session on Mercury Vapor Process, with paper by W. L. R. Emmet.

Conference on Industrial Education under the auspices of the A. S. M. E. Committee on Education and Training in the Industries.

Power Problems of Steel Industry (Gas Power and Power Divisions). "General Power Problems," Bryant Bannister. "Steam Problems," John A. Hunter. "Gas Power Problems—Use of Gas Engine in Steel Works," A. E. Banks.

Materials Handling in Industrial Plants (Materials Handling and Forest Products Divisions). "Economics of Materials Handling," by M. L. Begeman. "Continuous Assembly of Automobiles," M. R. Denison. "Materials Handling in Tire Manufacturing," W. C. Hoover. "Wood Handling from the Railroad Car to the Cut-Off Saw," B. Nagelboort and Thomas D. Perry.

General Session on Windmill and Fan Design. "Performance of Centrifugal Fans for Electrical Machinery," C. J. Fechheimer. "Wind Power," F. J. Pancratz.

Machine Shop Session (Machine Shop Practice Division). "British Machine Tool Design," W. E. Sykes.

Cleveland Power Session. "Pulverized Fuel," Mr. Aldrich. "High Pressure Pumping," L. A. Quayle. "Determination of Heat Losses through Insulating Material," R. H. Heilman (by title).

Joint Aeronautic and Ordnance Session. "Aerial Bombing," Maj. A. H. Hobley. "The War's Impress on the Steel Industry," A. E. White.

Measurement of Management (Management Division). "The Measurement of the Cost Accounting Function," Messrs. Jordan and Lamb. "The Mesaurement of the Quality of Product," G. W. Radford. "The Measurement of Efficiency of Plant, Equipment and Methods," W. L. Conrad.

Public Hearing on Power Test Codes—Condensers and Gas Producers.

Topical Discussion on Materials at High and Low Temperatures (joint session with A. S. T. M.) "Industrial Application of Metals at Various Temperatures," L. W. Spring. "Methods of Testing at Various Temperatures and Their Limitations," V. T. Malcolm. "Available Data on the Properties of Irons and Steels at Various Temperatures," H. J. French. "Available Data on the Properties of Non-Ferrous Metals," A. E. White and H. W. Upstegrove.

Tooling and Gaging for Interchangeable Manufacture (Machine Shop Practice Division). "Analysis of a Machine Shop Problem on a Quantity and Final Economy Basis," A. L. DeLeeuw.

Joint Session with A. S. R. E. "Temperature Measurement," P. Nicholls. "Heat Transfer," Edgar Buckingham.

Recent Developments in Heavy Electric Locomotives. Papers by N. W. Storer and W. B. Potter.

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Of special interest to our readers is the wide range of engineering courses that will be given this year at the Summer Session of the Carnegie Institute of Technology. The summer work, which will cover both theoretical class room instruction and shop practice, is outlined, according to an announcement, to be of special benefit to under-graduates and to those engaged in engineering work who feel a need for more technical training in their respective fields. Courses of six and eight weeks will be given, beginning June 16.

The College of Engineering will give courses in Chemistry, Physics, Mechanics, Engineering Drawing, Descriptive Geometry, and Surveying. A special short course in Coal Mining will be given in co-operation with the U. S. Bureau of Mines.

## Recent Patents—British and Foreign

Riveted joints. No. 190,339, British. C. E. Tetlow, Hollinwood.

To increase the efficiency of riveted joints for boilers, kiers and like vessels subjected to fluid pressure, the shell plates, etc., are welded to prevent leakage, and the riveted joint is then designed purely from considerations of strength. Figures show the pitch of the third row of a treble riveted double butt joint when the spacing of the rivets is determined from considerations of leakage and of strength respectively.

Electric transformers. No. 190,378 British. Western Electric Company, Ltd., Westminster.

A transformer comprises primary and secondary windings wound on the central part of a core, which projects an equal distance from each end of the windings, and a winding which is loosely coupled to the other windings by winding it on one of the projecting ends of the core. The transformer is particularly adapted for use in telephone substation circuits, the winding acting both as a transformer winding and as a balancing network.

Manufacture of gas. No. 190,819 British. T. W. S. Hutchins, Northwich.

Coal, oil shale and the like are distilled by being charged from a hopper into a trough from which a scoop, attached to an inner rotary tube, feeds the material through this tube, from which it passes through holes into an outer rotary tube, to which the inner tube is secured at an end, the material being finally discharged into a hopper. The inner tube is provided with a tumbler having radiator arms and adapted to knock or scape off any caked material in the tube; a similar tumbler may be provided in the outer tube, which is heated by hot gases in flues. The tubes are rotated by gearings, and the distillates escape through a pipe. A flexible joint between the tube and chamber comprises a diaphragm carrying a jointing ring held against a collar on the tube by tension springs.

Furnaces, retorts, etc. No. 190,919 British. S. E. George, Kidderminster.

An air or gas-tight door for furnaces, retorts and the like of the kind, in which the door is pivoted to its frame by a swinging link to allow the door a limited movement at right angles to the plane of the door opening is pressed against its seat by a pivoted bar, the ends of which are tapered and engage with brackets on the door frame. When the door is of substantial size, projecting ribs are formed on the door above and below the pivot and brackets. The ribs may be provided with stops to limit the movement of the bar. Lugs on the door are connected by a pin to an intermediate member, which is hinged to the lugs on the door frame. Packing may be arranged in a groove formed in the machined seating of the door to assist in making a tight joint.

Centrifugal blowers. No. 191,050 British. Akt.-Ges. Brown, Bovert et Cie, Baden, Switzerland.

A centrifugal blower for gases or vapors which are to be excluded from the atmosphere, has a rotor mounted on a flexible shaft connected by speed multiplying gearings to the slow-motion shaft. This apparatus is enclosed by a common fluid-tight casing. A simple packing ring is provided at the place where the slow shaft leaves the casing since labyrinth packings are provided on the shaft.

Metals and alloys. No. 191,167 British. W. L. Turner, Caldy, Cheshire.

In the production of metals and alloys such as manganese, cobalt, ferro-tungsten, ferro-vanadium, and ferro-titanium, by a thermo-aluminic process, a portion of the reaction mixture contains aluminum in powdered or finely granulated form, and another portion contains aluminum in relatively large pieces, the two portions being brought into reaction successively or together. In some cases, as in the manufacture of iron, practically all the aluminum may be in the larger form. The larger aluminum may be in the form of sheet cuttings, scrap, shavings, borings, etc., and aluminum alloys may be used in some cases.

Furnaces. No. 191,378 British. Westinghouse Electric & Manufacturing Company, East Pittsburgh, U. S. A.

The formation of clinker is prevented by injecting aqueous medium into the fuel bed at points of incipient clinker formation. The method is described in connection with an underfeed stoker comprising series of tuyeres with intervening retorts and a clinker pit. Mounted in channels in the sloping faces of air boxes, on opposite sides of the pit are distributing headers, through which water or steam or mixtures thereof, and it may be air also, is discharged into the burning refuse. The header may be omitted where the pit is of comparatively small width.

Oil gas. No. 191,411 British. E. Robinson and M. Robinson, Sydenham.

Apparatus for generating gas from liquid hydrocarbon and water consists of an auxiliary steam boiler which supplies steam to a heater containing heating coils, through which hydrocarbon and water circulates, the hydrocarbon and water then passing to a retort which is heated by superheated steam from the boiler to a temperature sufficient to vaporize the liquids. The hydrocarbon and water is supplied to the coils by a duplex pump, and the water from the coil is arranged to be sprayed into the retort to mix with the hydrocarbon admitted thereto by a pipe from the coil. The produced gas is then delivered to a scrubber, whence it passes to a burner to which may be led an auxiliary supply of oil through a pipe. When the burner is used for steam raising purposes, the auxiliary boiler may be dispensed with after starting up. The furnace front is secured by lugs to the boiler front and is provided with adjustable doors adapted to open and close upon hinges to regulate the inflow of air to the furnace.

Furnaces. No. 191,622 British. T. A. Rutherford and H. J. Pickles, Stockton-on-Tees.

A reversing-valve of the pivoted-hood type carried by four rocking-arms mounted on shafts is counterbalanced by weights connected to arms secured to extensions of the shafts on each side of the valve casing.

Ignition System. No. 1,441,451, American. Walter W. Riedel, Dayton, O.

In an ignition system, the combination with an internal combustion engine provided with an electrically ignited fuel burner; of a source of current; ignition apparatus including a circuit interrupter; means controlling said interrupter for producing in recurrent sequence a series of sparking impulses certain of which are of greater intensity than the others; and means for distributing the sparking impulses, said means being constructed so that the impulse of greater intensity will be conducted to the burner plug and one engine plug connected in series.

Following is a resume of some of the leading articles and trade reports appearing in Iron Trade Review, April 3 to April 24:

**April 3—**

At the opening of the second quarter pig iron producers are well supplied with orders, but new buying is light. Prices are fairly firm on a basis of $22 to $23 for No. 2 foundry iron, valley, and $21.75 to $22 valley for basic. Iron Trade Review's composite of leading iron and steel price this week is $42.91 compared with $43.13 in the week preceding. Pig iron production in March was 2,435,813 tons compared with 3,072,165 tons in February. The March average represented 89 per cent of the record figure of iast May. Automobile production is showing evidence of some retrenchment and railroad buying is less prominent, but other steel consuming lines are well maintained.

An indictment voted by the federal grand jury at Cleveland accuses 47 companies, members of the American Malleable Casting Association of violating the anti-trust law. The Association denies the charge that there has been any agreement with respect to prices, elimination of competition or the "Parceling" of customers.

Charles A. Barnes, treasurer of the Steel Scrap Company and vice president of the Perry, Buxton, Doane Company, Philadelphia contributes an article to this issue on the salvaging of hulls of battleships. About 10,000 tons of material heretofore lost in scrapping each ship now is reclaimed by a method of cutting up hulls at navy yards and the cost of work is comparatively low. W. H. Rastall, chief industrial machinery division, department of commerce, Washington, outlines in this issue opportunities open to American tool builders in foreign markets. The greatest chance for American participation lies in the field formerly dominated by German machinery exporters. American exports of metalworking machines now are below prewar levels while those of Great Britain are above.

Another chapter on the subject of heat treating—its principles and applications, is presented in this issue dealing with hardening and tempering. The series of articles on this subject by Charles H. Fulton, Hugh M. Henton and James H. Knapp are attracting the attention of steel treaters throughout this country and abroad.

A New Orleans company specializing on saw and sugar mill machinery has installed an electric furnace to make railroad castings. Some interesting features of this development are set forth in an article entitled "Making Electric Steel in Louisiana".

**April 10—**

Iron Trade Review's composite of 14 leading iron and steel products this week is down to $42.55 from $42.91 in the week preceding. This reflects the continuing weakness in pig iron and some finished steel products, especially in plates.

Steel ingot production in March attained the daily average of 159,455 tons, a record never before equalled in this country. This was at an annual rate of 49,590,000 tons. The best previous record was in April, 1923, with a daily average of 157,776 tons, an annual rate of 49,060,000 tons. The total output in March was approximately 4,145,829 tons. Some capacity is being taken off and the outlook for April production is not so encouraging, the steel corporation plants this week operating at 93 per cent which is 2 per cent to 3 per cent less than their recent rate. The trend of the steel market is indicated by the fact that on an inquiry of 40,000 tons of plates, shapes and bars for the Chesapeak and Ohio Railroad a bid of 2.10c, Pittsburgh was submitted. Concessions of $2 to $3 or more on sheets are failing to stimulate buying and the sheet bar price is being shaded to $41.

Reduction of 80c per ton has been made in the price of Lake Superior iron ore, which it is believed will compel some of the smaller operators to close their mines or work at a loss. The Ford Motor Company placed the bulk of its 250,000 ton order at a higher price than the market and before the market price was established, owing to special considerations. Iron Trade Review's European manager cables from London that a new corporation has been formed in South Wales and controls two thirds of the tin plate export trade. France's production of pig iron and steel in February was the largest for any one month since the close of the war, the output of pig iron being 590,000 metric tons and of steel 555,000 tons. E. C. Kreutzberg associate editor of Iron Trade Review in New York contributes an article to this issue describing conditions that confront American purchasers of European steel. He compares prices and points out difficulties the American purchasers have in obtaining material according to analysis on American standards. Contract clauses strongly favor the sellers, unless the American are represented abroad or inspect the material before purchase.

The U. S. Supreme Court decides that the Federal Trade Commission has no right to the private papers pertaining to the affairs of tobacco producers, ruling substantially as did the lower courts in the case of the Claire Furnace Company. This is considered in some quarters as sustaining the furnace operators and their refusal to comply with the trade commissions demand for report. E. C. Boehringer editorial representative of Iron Trade Review at Chicago presents the results of a survey of the rail steel products industry. The French correspondent of Iron Trade Review describes a new foundry school established in Paris for foundry engineers and managers. C. H. Hunt, chief engineer of the Weirton Steel Company contributes an article descriptive of the company's 37 new by-product ovens. This company is pioneering in the use of the new type of narrow oven, coking high volatile coals exclusively.

**April 17—**

Iron Trade Review's composite price this week stands at $42.47 compared with $42.55 in the week preceding. The pig iron market continues dormant and prices are lower. Steel buyers are holding back until prices settle although new requirements are strikingly large in those fields which for months have been the main support of the market, building work and the railroads. The Lake Superior iron ore market is the quietest in years notwithstanding the drastic reduction in price. The open market sales to date probably do not exceed 500,000 tons, while large consumers have reduced their estimates of requirements over the season.

# *Time Element in Iron Ore Reduction*[1]

## A Series of Experimental Determinations Which Suggest Very Low "Volume of Efficiency of Reduction."

By **P. H. ROYSTER**[2], **T. L. JOSEPH**[3] and **S. P. KINNEY**[4]

DURING the course of certain experiments carried out by the Bureau of Mines at the University of Minnesota, the writers obtained data bearing on the question of the time required for the reduction of iron ore in the blast-furnace. This information is of considerable interest to a study of the metallurgy of iron, and may prove useful in blast-furnace design and operation.

*View of experimental furnace at the University of Minnesota. Observer determining "reduction zone" with water-cooled gas-sampling tube.*

After ore is charged at the stock-line of a furnace, little is known of the subsequent physical and chemical conditions to which it is subjected, or of the details of the changes it experiences as a result of these conditions. When the charge finally appears as metal in the hearth, it has been reduced, melted, carburized, and contaminated with a small quantity of metalloids. The final result is of course known, and for many purposes perhaps it suffices to know the total sum of the reactions that have taken place during the 15 to 20 hours taken for the passage of the ore through the furnace. Nevertheless, it has seemed worth while to the writers to study the rate at which the known reactions take place, and to determine as definitely as possible at what place these reactions occur.

Although such phrases as the "zone of reduction", "zone of calcination" and the like appear frequently enough in the language of technical literature, little evidence as to the size, extent, and position of these zones can be found. In fact, so little is known that it is not possible definitely to assume that the regions in which the various reactions take place are zones at all.

### Methods of Measuring the Rate of Reduction.

Two obvious methods of measuring the reduction rate in the Bureau's experimental furnace were attempted with some success. The first which will be called the "test-charge" method, is easily carried out, and determines in a most direct manner the average time-rate of reduction. The second will be called the "sample-tube" method, and measures in greater detail, if somewhat less directly, the space-rate of reduction. The results of the two methods, though experimentally independent, are measurements of the same quantity, and they should be concordant. In the general case, the time-rate or the space-rate of any reaction is readily calculated one from the other, if the speed of stock descent is known.

In carrying out the test-charge experiments, the furnace was operated on two burdens alternately—one a blank charge of coke and manganiferous slag; the other, a charge of coke and iron ore. Continuous sampling of the gas from the down-comer was maintained during the transitions from one burden to the other, and from the analyses of these top-gas samples it is possible to follow the course of the reactions taking place as the ore settles in the shaft.

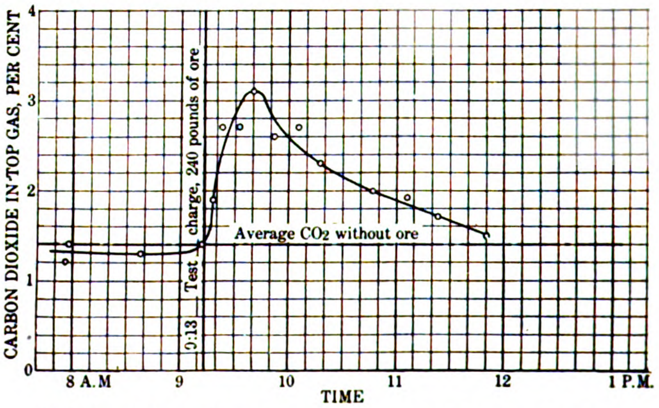

FIG. 1—*Effect of one test charge on top gas composition.*

**In the sample-tube method as carried out by the writers, the furnace was operated as steadily as pos-**

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[1] Fourth of series. Published by permission of the Director, U. S. Bureau of Mines.

[2] Asst. metallurgist, North Central Station, Minneapolis, Minn.

[3] Assoc. metallurgist, North Central Station, Minneapolis, Minn.

[4] Asst. metallurgist chemist, North Central Station, Minneapolis, Minnesota.

sible on a normal charge of coke, ore, and limestone. Water-cooled sample tubes were introduced through holes in the furnace wall at five elevations, and gas samples were withdrawn at various distances between the center and the wall. Such a systematic series of samples from the interior of the shaft makes it possible to determine the regions of chemical activity with a fair degree of accuracy. Since the rate of speed at which the charge settles was measured, it is possible to convert the space-rate determined by this experiment into time-rate units. The relation between these two tests will perhaps better be discussed after the results of the tests are presented.

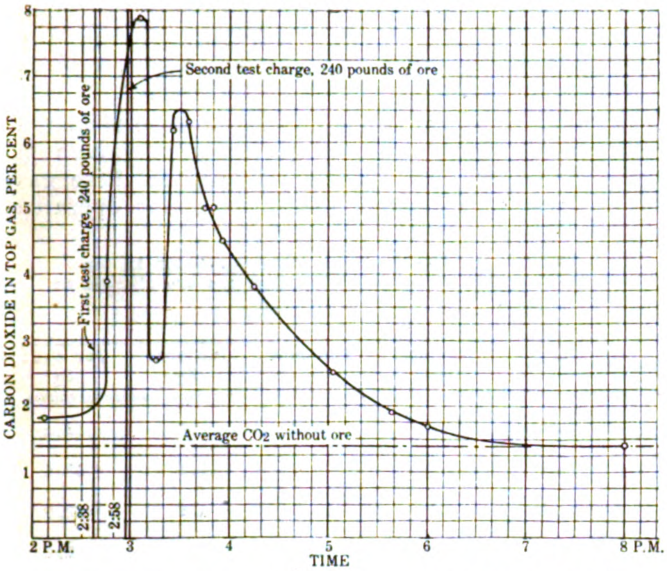


FIG. 2—*Effect of two test charges on top gas composition.*

### Test-Charge Method.

The blank charge, used alternately with the ore charge, contained 120 lb. of coke and 160 lb. of slag. The composition of this slag, produced during previous experiments, averaged 30.7 per cent $SiO_2$, 8.6 per cent $Al_2O_3$, 32.6 per cent MnO, and 4.5 per cent FeO. An analysis of the coke used has already been published, as well as the lines of the experimental furnace[5]. With this material in the charge the top gas had this composition:

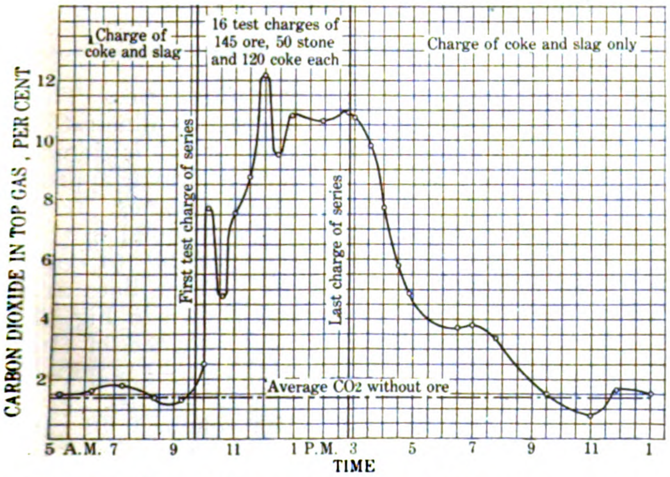
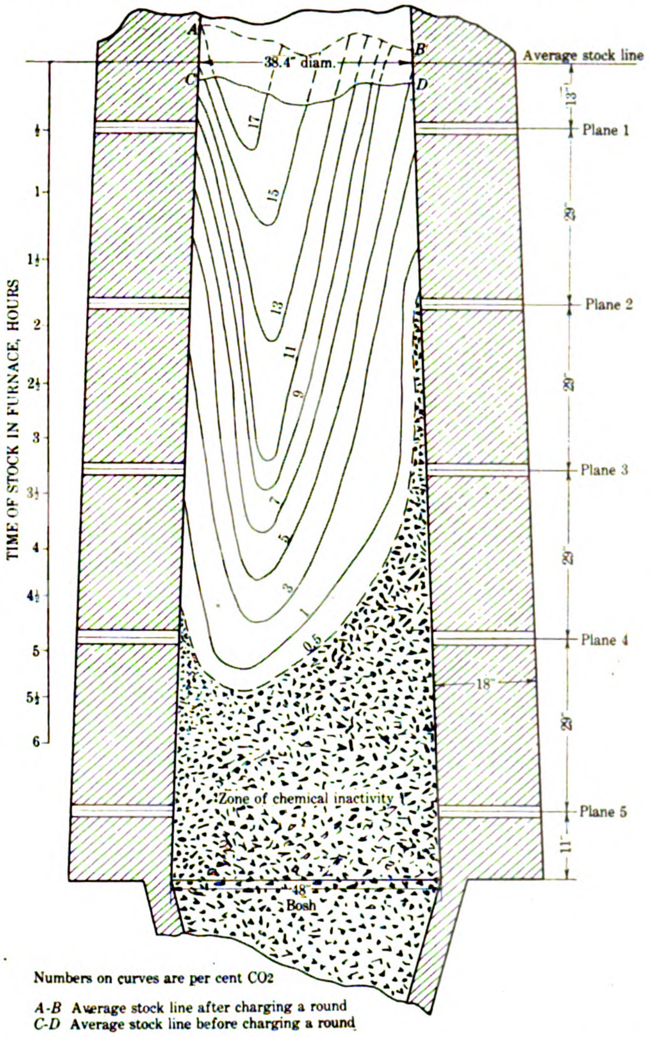


FIG. 3—*Effect of 16 rounds of ore and lime stone on top gas composition.*

| Constituent | Per cent |
|---|---|
| $CO_2$ | 1.39 |
| CO | 33.36 |
| $H_2$ | 1.52 |
| $N_2$ | 63.73 |

a result obtained from averaging 55 gas samples taken during 48 hours of operation. In theory, the blank charge should give a gas containing no $CO_2$. Actually the slag is seen not to be free from iron, and the coke itself carried 2.24 per cent iron, so that under this "slagging type gas producer" operation, about 25 lb. of spiegeleisen was produced per hour, the manganese in the slag not proving wholly irreducible. In the first of the test-charge experiments a single round of 240 lb. of iron ore was charged at 9:13 a.m. The slag burden was restored immediately, and continued until the effect of the test charge had been dissipated. The ore contained 52.13 per cent Fe, 11.13 per cent $SiO_2$, 1.22 per cent $Al_2O_3$, and 0.39 per cent CaO + MgO. The gas analyses taken in this test are recorded in Table I, and the $CO_2$ content of the top gas, plotted against time, is shown in Fig. 1.



Numbers on curves are per cent CO2

*A-B* Average stock line after charging a round
*C-D* Average stock line before charging a round

In the next experiment, two successive charges of 240 lb. of iron ore (no flux was used) were made, one 20 minutes after the other. (The bell was lowered at 2:38 and 2:58 p. m.) The gas analyses from this experiment are shown in Table II and the $CO_2$ content of the gas is presented graphically in Fig. 2.

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[5] P. H. Royster, T. L. Joseph, and S. P. Kinney, "Reduction of Iron Ore in the Blast Furnace," *The Blast Furnace and Steel Plant*, vol. 12, January, 1924, pp. 35-37.

The third experiment consisted of charging 16 successive rounds containing 120 lb. of coke, 145 lb. of ore, and 50 lb. of limestone, commencing at 9:35 a. m., the sixteenth test round going into the furnace at 2:47 p. m. The variation in the $CO_2$ content of the gas with time is shown in Fig. 3, and the gas analyses in Table III. These three experiments will be referred to as test-charge experiments 1, 2, and 3.

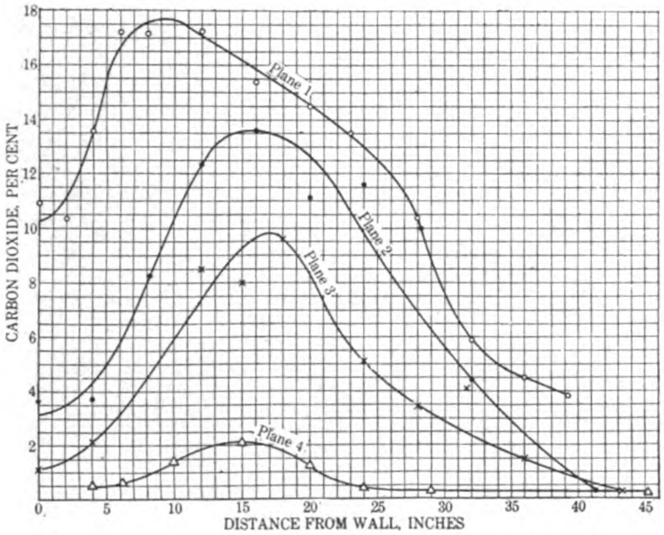

FIG. 6—*Variation in $CO_2$ content of gas across four planes.*

## Sample-Tube Method.

The position of the holes in the mantle brickwork through which the water-cooled tubes were introduced is shown in Fig. 4. A triple-walled sample tube of obvious design was used. Two platforms were built to facilitate the gas-sampling work. Fig. 5 is a photograph of the stack, an observer being shown on the scaffold taking samples from plane 3. The gas samples were taken under mercury in the manner described by Perrott and Kinney[6]. Together with the analysis of the gas, a record was kept of the time of sampling and the distance from the wall. The distances were measured from points on the wall over No. 2 tuyere (left side of Fig. 4). This tuyere was 3 inches in diameter and No. 1 tuyere only 2.5 inches. This caused a more rapid settling of the stock on the left side of the furnace. The skip dumped from right to left, and this caused more than half of the charge to fall onto the left half of the stock-line; consequently the stock descent was not symmetrical about a plane perpendicular to the center line of the tuyeres.

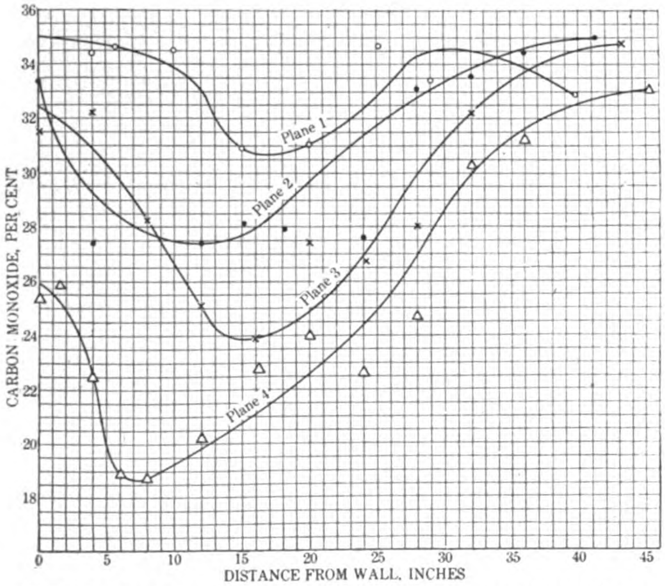

FIG. 7—*Variation in CO content of gas across four planes.*

The analysis of the gas found in the several planes at various distances from the left wall is given in Tables IV, V, VI, VII, and VIII. While these gas samples were being taken, the furnace was operated as described in the January paper of this series. The variation in $CO_2$ content across furnace is illustrated in Fig. 6, and a similar set of curves for CO is shown in Fig. 7. In these figures a curve is drawn appropriately marked for each of the top four planes. It is seen from Table VIII that no $CO_2$ was found in the fifth plane. From these data it is possible to construct "lines of equal $CO_2$ content." These lines are drawn on the section of the furnace shown in Fig. 4. In the lower portion of the furnace (shaded in the figure), no reduction — direct or indirect — is going on. This region is the so-called idle or inactive zone mentioned in a previous paper[7]. Its volume is 81 cu. ft., while the volume of the chemically active region is 78 cu. ft., the sum of the two, 159 cu. ft., being the volume of the furnace included between the stock-line and plane of the tuyeres. For practical purposes gas containing less than 0.5 per cent of $CO_2$ has been

**TABLE 1. : Single Charge Test: Variation in top gas composition when 240 lb. iron ore are charged at 9:13 a.m.**

| Sample No. | Time | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ |
|---|---|---|---|---|---|
| 1 | 7:56 a.m. | 1.2 | 34.0 | 2.6 | 62.2 |
| 2 | 7:58 | 1.4 | 34.7 | 1.5 | 62.4 |
| 3 | 8:38 | 1.2 | 34.3 | 1.6 | 62.9 |
| 4 | 8:58 | 1.3 | 35.4 | 1.1 | 62.2 |
| 5 | 9:12 | 1.4 | 34.2 | 1.4 | 63.0 |
| 6 | 9:18 | 1.9 | 34.0 | 1.8 | 62.3 |
| 7 | 9:23 | 2.9 | 26.5 | 2.9 | 67.7 |
| 8 | 9:31 | 2.9 | 29.4 | 2.5 | 65.2 |
| 9 | 9:40 | 3.1 | 29.5 | 2.1 | 65.3 |
| 10 | 9:52 | 2.6 | 29.8 | 1.6 | 66.0 |
| 11 | 10:05 | 2.7 | 28.6 | 2.4 | 66.3 |
| 12 | 10:18 | 2.3 | 29.4 | 2.6 | 65.7 |
| 13 | 10:47 | 2.0 | 30.8 | 2.7 | 64.5 |
| 14 | 11:07 | 1.9 | 29.4 | 2.3 | 66.4 |
| 15 | 11:23 | 1.7 | 34.2 | 1.2 | 62.9 |
| 16 | 11:50 | 1.5 | 30.8 | 1.7 | 66.0 |

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[6] G. St. J. Perrott and S. P. Kinney, "Combustion of Coke in the Blast-Furnace Hearth," Trans., Amer. Inst. Min. Met. Eng., vol. 69, 1923, p. 543.

[7] P. H. Royster, T. L. Joseph, and S. P. Kinney, "Progress in Blast-Furnace Research," Bureau of Mines Report of Investigations, Serial No. 2524, Sept. 1923, 6 pp.

taken to be essentially unaltered bosh gas. The dotted line in Fig. 4, representing 0.5 per cent $CO_2$, is assumed to divide the active from the inactive region.

### Comparison of Results.

A study of Figs. 1, 2, and 3, leads to the conclusion that reduction of the ore takes place remarkably close to the stock-line. In the first test charge experiment, the $CO_2$ in the top gas reached a maximum about 28 minutes after the ore had been charged. The $CO_2$ curve for the second test (Fig. 2) exhibits two maxima, the first occurring 26 minutes after the first ore was charged, the second maximum being reached 31 minutes after the second round entered the furnace. In the 16-round experiment, the first ore was dropped on the stock-line at 9:40 a. m. The first peak on the $CO_2$ curve is found at 10:05 a. m. The rate of reduction therefore appears to have reached a maximum according to the average of there four determinations, 27.5 minutes aftre the ore was charged. The stock-line was found to settle regularly at a rate of 0.418 inches per minute, this figure being the average of several hundred measurements. The center of the test round was therefore 11.5 inches (27.5 × 0.418) below the stock-line when the $CO_2$ curve reached its maximum. This would plac ethe point of maximum rate of reduction at 1.5 inches above plane 1.

TABLE II - Double Charge Test: Variation in top gas composition when 240 lb. iron ore are charged at 2:38 p.m. and 240 lb. at 2:58 p.m.

| Sample No. | Time | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ |
|---|---|---|---|---|---|
| 1 | 2:08 P | 1.8 | 33.9 | 1.8 | 62.5 |
| 2 | 2:45 | 3.9 | 31.6 | 1.8 | 62.3 |
| 3 | 3:05 | 7.9 | 27.4 | 1.7 | 63.0 |
| 4 | 3:15 | 2.7 | 33.6 | 1.5 | 62.2 |
| 5 | 3:25 | 6.2 | 27.5 | 1.7 | 64.6 |
| 6 | 3:34 | 6.3 | 29.4 | 1.7 | 62.6 |
| 7 | 3:46 | 5.0 | 30.5 | 1.6 | 62.9 |
| 8 | 3:50 | 5.0 | 30.7 | 1.6 | 62.7 |
| 9 | 3:56 | 4.5 | 31.3 | 1.6 | 62.6 |
| 10 | 4:15 | 3.8 | 29.9 | 1.9 | 64.4 |
| 11 | 5:03 | 2.5 | 33.5 | 0.3 | 63.7 |
| 12 | 5:39 | 1.9 | 33.7 | 1.7 | 62.7 |
| 13 | 6:00 | 1.7 | 30.7 | 2.4 | 65.2 |
| 14 | 8:00 | 1.4 | 34.4 | 1.1 | 63.1 |
| 15 | 9:50 | 1.2 | 34.4 | 0.6 | 63.8 |
| 16 | 10:50 | 1.2 | 34.0 | 1.8 | 63.0 |
| 17 | 11:50 | 1.2 | 34.4 | 1.1 | 63.3 |

The results of the sample-tube experiments shown in Fig. 4 point to a somewhat similar conclusion. The reduction of the ore is proportional to the rate at which the $CO_2$ content increases as the gas is forced up the shaft. This rate of increase is greater at plane 1 than at any other elevation in the furnace. The maximum rate of increase in the whole furnace occurs at the left wall of the furnace in plane 2, the $CO_2$ increasing 0.56 per cent per inch at that point. These conclusions are therefore consistent with each other, although they have been arrived at by independent methods. They are not, however, in strict accord with many conceptions of the mechanism of ore reduction. The gas in plane 1 shows an unexpectedly large $CO_2/CO$ ratio. The maximum value of 0.92, shown

TABLE III. - Variation in top gas composition when 16 rounds of ore and stone are charged.*

| Sample No. | Time | Per cent CO | Per cent CO | Per cent $H_2$ | Per cent $N_2$ |
|---|---|---|---|---|---|
| 1 | 5:15 a.m. | 1.5 | 33.9 | 0.5 - | 64.1 |
| 2 | 6:20 | 1.6 | 33.4 | 1.1 | 63.9 |
| 3 | 7:15 | 1.8 | 33.4 | 0.8 | 64.0 |
| 4 | 8:23 | 1.4 | 33.1 | 2.0 | 63.5 |
| 5 | 9:15 | 1.3 | 33.6 | 1.6 | 63.5 |
| 6 | 9:58 | 2.5 | 32.6 | 1.8 | 64.9 |
| 7 | 10:05 | 7.7 | 24.4 | 1.7 | 66.2 |
| 8 | 10:32 | 4.8 | 30.2 | 1.6 | 63.4 |
| 9 | 11:01 | 7.6 | 28.0 | 1.6 | 62.8 |
| 10 | 11:29 | 8.8 | 27.0 | 1.4 | 62.8 |
| 11 | 12:02 | 12.2 | 15.1 | 0.7 | 72.0 |
| 12 | 12:28 | 9.5 | 26.0 | 1.4 | 63.1 |
| 13 | 12:54 | 10.8 | 21.9 | 2.3 | 65.0 |
| 14 | 1:59 | 10.6 | ---- | --- | ---- |
| 15 | 2:45 | 10.9 | 25.7 | 1.3 | 62.1 |
| 16 | 3:00 | 10.8 | 25.8 | 1.4 | 62.0 |
| 17 | 3:39 | 9.8 | 23.2 | 2.6 | 64.4 |
| 18 | 3:58 | 7.7 | 28.8 | 1.2 | 62.3 |
| 19 | 4:30 | 5.8 | 30.3 | 1.5 | 62.4 |
| 20 | 4:56 | 4.9 | 26.3 | 1.8 | 67.0 |
| 21 | 6:30 | 3.7 | 25.2 | 2.8 | 68.3 |
| 22 | 7:06 | 3.8 | 23.7 | 3.1 | 69.4 |
| 23 | 7:40 | 3.4 | 27.8 | 2.8 | 66.0 |
| 24 | 9:30 | 1.5 | 28.0 | 2.8 | 67.7 |
| 25 | 11:00 | 0.8 | 33.1 | 1.1 | 65.0 |
| 26 | 11:50 | 1.6 | 33.6 | 1.6 | 63.2 |
| 27 | 1:00 | 1.5 | 33.0 | 1.1 | 64.4 |

* Each round 145 lb. ore, 50 lb. stone, 120 lb. coke. First round charged at 9:40 a.m.; last round at 2:47 p.m.

TABLE IV. - Gas Composition in Plane 1*.

(15 ft. 4 in. above tuyeres, 13 in. below stock line)

| Sample No. | Distance from wall in inches | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ | Per cent $CO_2/CO$ |
|---|---|---|---|---|---|---|
| 1 | 0 | 10.9 | 25.4 | 1.3 | 62.4 | 0.43 |
| 2 | 2 | 10.4 | 25.9 | 1.0 | 62.7 | 0.40 |
| 3 | 4 | 13.6 | 22.6 | 0.8 | 63.0 | 0.60 |
| 4 | 6 | 17.3 | 18.9 | 1.1 | 62.7 | 0.92 |
| 5 | 8 | 17.3 | 18.8 | 1.4 | 62.5 | 0.92 |
| 6 | 12 | 17.2 | 20.2 | 1.1 | 61.5 | 0.85 |
| 7 | 16 | 15.3 | 22.8 | 1.4 | 60.5 | 0.67 |
| 8 | 20 | 14.5 | 24.0 | 1.1 | 60.4 | 0.60 |
| 9 | 24 | 13.5 | 22.7 | 1.2 | 62.6 | 0.60 |
| 10 | 28 | 10.4 | 24.7 | 1.4 | 63.5 | 0.42 |
| 11 | 32 | 5.8 | 30.3 | 0.8 | 63.1 | 0.19 |
| 12 | 36 | 4.5 | 31.2 | 0.7 | 63.6 | 0.14 |

* Variation across the plane measured from sampling hole in wall over Tuyere No. 2.

in Table IV, is just double the theoretical maximum set by Bell[8]. The data presented here, if credited, may force the reader to conclude that gas containing say 16 per cent of $CO_2$ and 21 per cent of CO, acting on freshly charged ore, will cause reduction to take place at a somewhat greater speed than will gas at a higher temperature, carrying 4 per cent of $CO_2$ and 30 per cent of CO, acting on ore that has been preheated in the furnace during four hours. To many metallurgists this perhaps seems inconsistent with what is known of the speed of chemical reactions. However, there is an unexplored gap between the chemical science of reaction velocities and the metallurgical process of ore reduction. The Bureau's furnace experiments were planned to throw light on a definite metallurgical problem; hence, the data reported here are as ill-adapted to a study of chemical kinetics as many of the published laboratory experiments on ore reduction are to actual blast-furnace practice.

### Time and Volume Efficiency of the Furnace.

The question of ore reduction was considered in the first article of this series, but reduction was discussed there from th epoint of view of the furnace as a whole. It is evident from Fig. 4 that the phrase, "furnace as a whole", means little. In the lower part of the furnace no important chemical reactions seem to take place. In the upper part of the furnace, where chemical action is rapid, the rate of reduction is not uniform across a given section, nor along a line of flow either of the stock or of the gas.

TABLE V. - Gas Composition in Plane 2.

(12 ft. 11 in. above tuyeres, 3 ft. 6 in. below stock line)

| Sample No. | Distance from wall in inches. | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ | Per cent $CO_2/CO$ |
|---|---|---|---|---|---|---|
| 1 | 0 | 3.7 | 31.5 | 1.0 | 63.8 | 0.12 |
| 2 | 4 | 3.7 | 32.2 | 0.8 | 63.3 | 0.11 |
| 3 | 8 | 8.3 | 28.2 | 0.9 | 62.6 | 0.29 |
| 4 | 12 | 12.4 | 25.1 | 0.9 | 61.6 | 0.49 |
| 5 | 16 | 15.6 | 25.9 | 1.0 | 61.5 | 0.57 |
| 6 | 20 | 11.1 | 27.4 | 0.8 | 60.7 | 0.41 |
| 7 | 24 | 11.7 | 26.7 | 0.9 | 60.7 | 0.44 |
| 8 | 28 | 10.0 | 28.0 | 0.5 | 61.5 | 0.36 |
| 9 | 32 | 4.4 | 32.2 | 0.6 | 62.8 | 0.14 |
| 10 | 39 | 0.1 | 34.8 | 1.2 | 63.9 | 0.00 |

The data given in this report make it easy to study in considerable detail the intensity of reduction at any point in the furnace. The following example illustrates a method of calculating the reduction at any point in the furnace by means of the curves in Figs. 4, 6, and 7:

Let it be required to know the reduction going on at a point say 10 inches from the left wall and 20 inches below the stock-line, the degree or intensity of reduction being measured in the units: pound of oxygen removed from the ore per minute per cubic foot. Twenty inches below the stock-line the diameter of the shaft is 40.5 inches, the corresponding area being 8.96 sq. ft. The rate of increase of $CO_2$ content of the gas stream at this elevation and 10 inches from the left wall is seen from Fig. 4 to be about 4.4 per cent of $CO_2$ by volume per vertical foot. By weight this is equivalent to 7.0 per cent of $CO_2$. If the gas velocity be assumed to be uniform across the horizontal section, the flow of gas amounts to 3.7 lb. per sq. ft. per min. Hence, the gas stream gains 0.26 lb. of $CO_2$ per minute in passing through an element of volume one foot high and with a base of one square foot. This cubic foot element of volume therefore removes 0.096 lb. (4/11 × 0.26) oxygen from the ore contained in it per minute, since 7 lb. of CO removes 4 lb. of $O_2$ to form 11 lb. of $CO_2$. The total $O_2$ removed from the ore per minute by the whole furnace is 1.52 lb.[9]. It would take, therefore, nearly 16 cubic feet of furnace volume to carry out the required reduction.

TABLE VI. - Gas Composition in Plane 3.

(10 ft. 6 in. above tuyeres, 5 ft. 11 in. below stock line)

| Sample No. | Distance from wall in inches. | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ | Per cent $CO_2/CO$ |
|---|---|---|---|---|---|---|
| 1 | 2 | 1.6 | 30.2 | 1.5 | 66.7 | 0.05 |
| 2 | 8 | 5.4 | 27.2 | 1.2 | 66.2 | 0.20 |
| 3 | 13 | 8.3 | 27.7 | 0.6 | 63.4 | 0.30 |
| 4 | 15 | 5.6 | 30.6 | 1.1 | 62.7 | 0.19 |
| 5 | 17 | 6.4 | 30.5 | 0.9 | 62.2 | 0.21 |
| 6 | 19 | 7.2 | 29.6 | 0.7 | 62.5 | 0.24 |
| 7 | 22 | 5.0 | 29.5 | 0.8 | 64.7 | 0.17 |
| 8 | 26 | 4.3 | 30.4 | 0.9 | 64.4 | 0.14 |
| 9 | 30 | 3.9 | 33.4 | 0.9 | 61.8 | 0.12 |
| 10 | 34 | 2.9 | 34.2 | 0.7 | 62.2 | 0.08 |
| 11 | 38 | 0.9 | 34.8 | 0.7 | 63.6 | 0.03 |
| 12 | 41 | 0.2 | 34.9 | 0.7 | 64.2 | 0.01 |

A number of interesting conclusions could perhaps be drawn from this calculation. The total volume of the furnace is 159 cu. ft., and 16 cu. ft. would suffice for reduction if the conditions everywhere were as favorable for reduction as those existing 20 inches below the stock-line and 10 inches from the left wall. This point was selected more or less at random as being typical of the chemically active region. Although representing a fairly high intensity of reduction, it is not the maximum for the furnace. If it be admitted that one cubic foot furnace volume is enough working

(Concluded on page 254.)

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[8] I. L. Bell, "Chemical Phenomena In Iron Smelting": 1872.

[9] The furnace received 67.0 rounds per day, and each round lost 32.6 lb. of $O_2$. P. H. Royster, T. L. Joseph, and S. P. Kinney, work cited in *The Blast Furnace and Steel Plant*, vol. 12, Jan., 1924, p. 35.

# The POWER PLANT

## Economical Operation and Maintenance of Boiler Furnaces*

By ROBERT JUNE†

THE furnace volume required for the complete combustion of any fuel is dependent upon a good many variables, so that satisfactory calculation of furnace volume is extremely difficult. Among the factors to be taken into account are the chemical and physical qualities of the fuel, the system of combustion, the shape of the combustion chamber, the draft and distribution of air and the thoroughness with which air and fuel may be mixed.

The least amount of combustion space is required with oil, where modern mechanical atomization is employed. The largest amount of combustion space is required with pulverized fuel. In between lie all grades of lump coal.

**This is the sixth in a series of articles by Robert June, who is well qualified to write on this subject. The articles are written from the point of view of the managing executive and deal with the dollars and cents end of power plant operation and maintenance. Succeeding articles deal with such live topics as safe and efficient boiler operation and maintenance, what management should know about coal and ash handling equipment, steam piping, efficient turbine operation, etc. The service is timely and should prove of value to our readers.**

Furnace volume required is primarily dependent upon the thoroughness of the facilities for mixing air and fuel. Thus with modern oil burning equipment, the mixing is very largely done in the burner itself and complete combustion is secured within a few feet of the tip. With low volatile coals the greater part of combustion takes place within the fuel bed or directly above it. With high volatile, long flaming coals combustion is not completed until the gases have traveled a considerable distance from the fuel bed, and can possibly only be made complete through the employment of ignition arches.

With pulverized fuel, in the present state of the development of the art, there is little or no mixing of the fuel and air prior to their injection into the furnace. As a result very large furnace volumes are required in order to assure ample room for each particle of fuel to find the particle of air which it requires without the admission of large volumes of excess air. Some day, perhaps pulverized fuel engineers will succeed in designing burners which will so thoroughly mix the fuel and the air before their injection into the furnace, that combustion will be completed within a short distance of the burners. When this is done furnace volumes for pulverized fuel can be materially reduced.

Table I below shows the B.t.u. fired per hour per cubic foot of furnace volume at very high efficiencies, and which thus represent probably the best attainable results in actual practice. For this table as well as for Table II, we are indebted to Mr. E. B. Ricketts of the New York Edison Company.

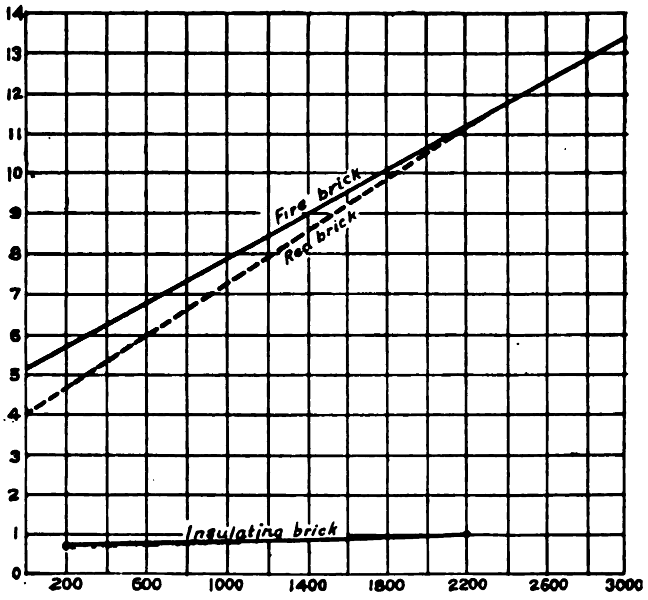

FIG. 1—*Bureau of Standards curves showing the relative conductivity of various bricks.*

TABLE I—B.T.U. FIRED PER HOUR PER CUBIC FOOT OF FURNACE VOLUME AT EFFICIENCIES OF ABOUT 80 PER CENT WITHOUT ECONOMIZERS

| Fuel Burning System. | B.t.u. per Cu. Ft. of Furnace Volume |
|---|---|
| Pulverized coal | 22,000 |
| Chain-grate stokers | 37,500 |
| Underfeed stokers | 64,000 |
| Locomotives | 70,000 |
| Oil — steam atomization | 85,000 |
| Scotch marine boiler hand fired | 144,000 |
| Oil — mechanical atomization | 176,000 |

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*Copyright, 1924, by Robert June.

†Associate Member A. S. M. E.

It was the practice 10 or 15 years ago for boilers to be provided with from 1 to 1.75 cubic feet of furnace volume per rated hp. Practice in recent years has differed radically from this, very much larger furnace volumes being provided. Table II shows the cubic feet of furnace volume per rated hp. of some of the important plants completed within the past five years.

TABLE II — CUBIC FEET OF FURNACE VOLUME PER RATED HORSE POWER.

(10 Sq. Ft. Boiler Heating Surface.)

| Station | Chain-grate Stokers | Under-feed Stokers | Pulverized Coal |
|---|---|---|---|
| RECENT STATIONS | | | |
| American Sugar—Baltimore | 2.00 | .... | .... |
| Kansas City | 2.57 | .... | .... |
| Dalmarnock — Glasgow | 3.10 | .... | .... |
| Barking — London | 3.87 | .... | .... |
| Calumet | 4.45 | .... | .... |
| Waukegan | 5.75 | .... | .... |
| Dodge Bros. | .... | 2.17 | .... |
| Seward | .... | 3.24 | .... |
| Colfax | .... | 3.45 | .... |
| Springdale | .... | 3.95 | .... |
| Hell Gate | .... | 4.23 | .... |
| Gennevilliers — Paris | .... | 4.50 | .... |
| South Meadow | .... | 4.56 | .... |
| Delaware | .... | 4.80 | .... |
| Lakeside | .... | .... | 4.66 |
| River Rouge | .... | .... | 4.98 |
| Cahokia | .... | .... | 6.52 |
| OLDER STATIONS | | | |
| Waterside | .... | 1.05 | .... |
| Essex | .... | 1.95 | .... |
| Muscle Shoals | .... | 2.19 | .... |
| L. Street | .... | 2.43 | .... |
| Conners Creek | .... | 2.72 | .... |

The question naturally arises, are these increased furnace volumes more economical than smaller furnace volumes. The answer is that the larger furnace costs relatively more, but not proportionately more to build and maintain than the smaller furnace. The justification for the larger furnace must necessarily be found in increased boiler efficiency and capacity. It is the general consensus of opinion of combustion engineers that despite heavier maintenance costs the tendency towards larger furnace volumes is justified.

This justification is found in the higher evaporation rates and higher efficiencies now being demanded and secured. What we are doing is working existing equipment several times harder than was the practice only a few years ago. Despite increased costs of fuel, the cost of producing power is either remaining stationary or decreasing slightly. It is paying to work apparatus hard.

**Conditions the Furnace Must Meet.**

As a result of the larger quantities of fuel going into the furnace with the higher evaporation rates, fuel beds are thicker than formerly and therefore draft must be increased. We have higher temperatures inside the furnace and as stated higher height and greater volume. The furnace, therefore, must have sufficient strength to support itself at all temperatures regardless of loads or stresses which may be applied to it.

Inside the furnace we will have temperatures over considerable lengths of time of 2800 deg. to 3000 deg. F. While exposed to this temperature the furnace wall must stand up under the erosion and attrition of ash and clinker flowing over it. It must resist the attack of the fireman's slice bar while he endeavors to break off lumps of clinker and molten ash. The furnace lining must not be chemically active with either the ash or clinker as such a condition will cause it to flux rapidly. Porocity must be at a minimum, otherwise there will be a considerable inseepage of air through the walls lowering the furnace temperature, wasting heat and fuel and hastening the spalling of the refractory in the furnace. Radiation losses must also be avoided.

These several requirements of the furnace—higher refractory quality—physical strength, surface hardness, low expansion and contraction coefficient over a wide temperature range, low heat conductivity, imperviousness — are all of the greatest importance.

**The Refractory.**

The particular requirements of the modern boiler furnace wall are so widely varied that no one material can meet them all 100 per cent. Therefore, the tendency is toward the use of two or three or even four materials. Table III gives the thermal properties of various refractories.

TABLE III — THERMAL PROPORTIONS OF VARIOUS REFRACTORIES

| Material | Fusion point Deg. F. | Point of failure under 50 lbs. per sq. in load Deg. F. | Thermal conductivity at 1832 Deg. F. B.t.u. per hr. per Deg. F. per inch. | Specific heat at 212 Deg. F. | Resistance to spalling. |
|---|---|---|---|---|---|
| Fireclay | 3092 | 2462–2552 | 11.3 | 0.199 | Good |
| Silica | 3092 | 2912 | 12.7 | 0.219 | Poor |
| Magnesia | 2929 | 2696 | 22.9 | 0.231 | Poor |
| Chrome | 3722 | 2597 | 16.5 | .... | Poor |
| Bauxite | 3245 | 2462 or more | 11.3 | .... | Good |
| Zirconia | 4667 | 2750 | Low | .... | .... |
| Carborundum | 4064 | Above 3002 | 67.0 | 0.186 | Good |
| Alundum | 3722 | Above 2822 | High | 0.198 | Good |

Examination of the above table would give the impression that a satisfactory combination of materials for all practical purposes could be made from it. This would be true if we could eliminate the item of cost of material. Some of the refractories in this table, however, are so expensive that they can only be used in special ways. Therefore, it is necessary to rely upon fire clay products for the bulk of our boiler wall work.

**Furnace Difficulties.**

Furnace deterioration usually starts at the joints between bricks. Every joint and every layer of binding material is a possible source of weakness.

Each brick has its individual characteristics of shape, size and uniformity of mixture of its component materials. Therefore, expansion and contraction of the various bricks in the wall are not uniform. Bricks not true to size and shape exert a side thrust adjacent bricks. Bricks not properly baked and tempered or not uniformly mixed crack with sudden temperature changes.

Probably the most prolific source of failure is the erosion of fire brick by molten ash. It is true this is not a problem where coals having ash fusion temperatures of 2700 deg. to 2800 deg. are used, but there are very few power plants today which enjoy the use of coals of this quality. Whereas, it is every day experience in thousands of plants to deal with coals the ash of which begins to soften at 2100 deg. and runs at 2300 deg.

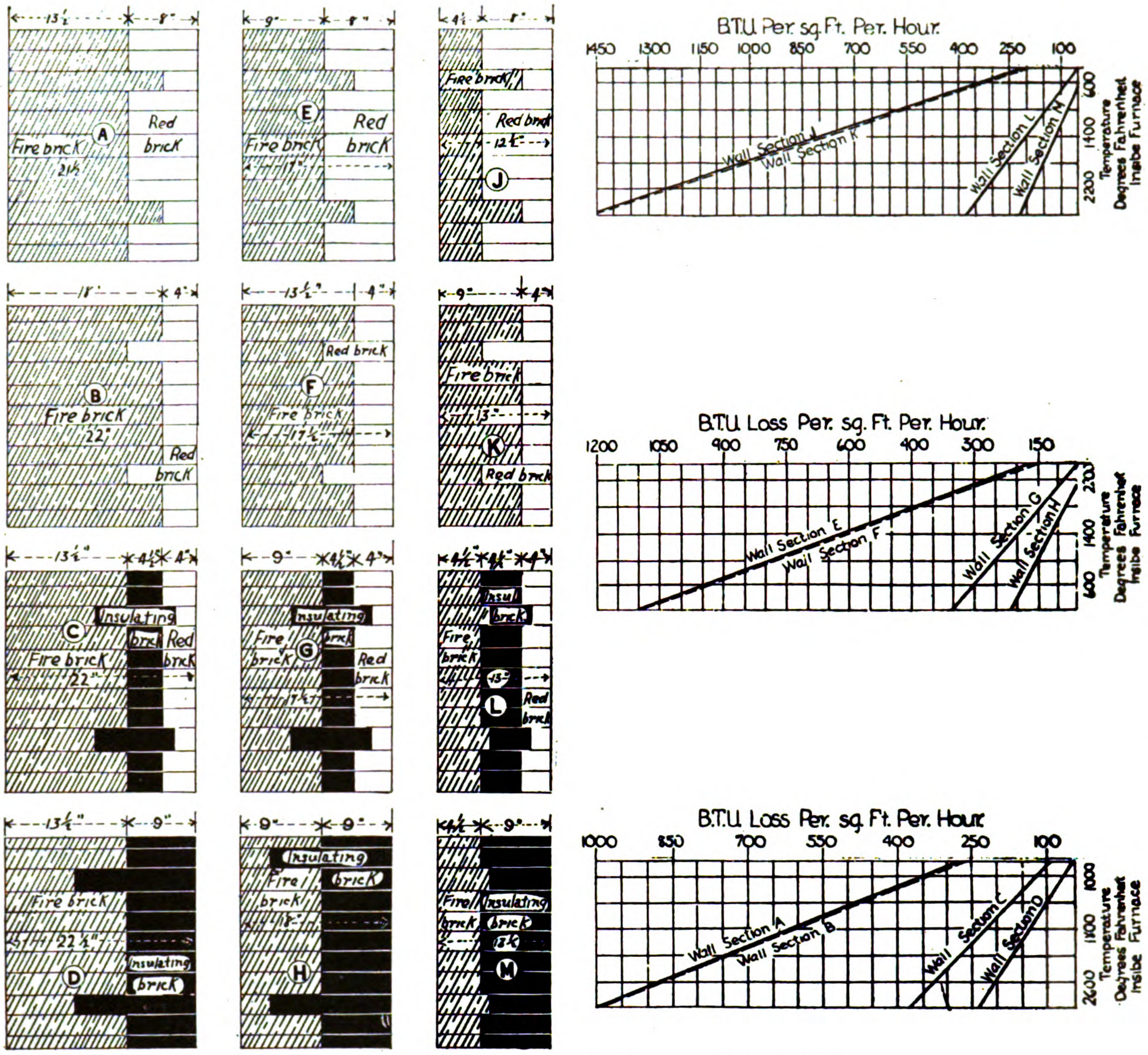


FIG. 2—*Graphic presentation of preventable radiation losses.*

Ash erosion becomes a serious matter with pulverized coal or where underfeed stokers with forced draft are used. In such furnaces a vertible sand blast action is produced. The flames, carrying small particles of molten ash, are driven into the cracks and pores of the brick work. The surface then becomes a mixture of fire brick and ash which has a much lower melting temperature than the fire brick.

Now if the temperature of the surface of the brick is lower than that of the molten ash, the ash will not penetrate into the brick to any great extent but will form a pasty coating over it. Then there will not be a great deal of erosion. If, however, the surface temperature of the brick is the same as that of the ash, due to higher gas temperatures and better insulation, some of the molten ash will penetrate into the brick and erosion will take place. If gas temperatures and insulation effect are increased still further so that the temperature an inch beneath the surface of the wall is the same as that of the ash, then the molten ash will literally wash the brick away rapidly.

While we have just referred particularly to the increase in temperature of furnace gases, we must bear in mind that this is a matter over which we do not have any particular control, and further that the depth of penetration of high temperature in the furnace walls is largely controlled by the material with which the wall is constructed as well as its thickness. Right away we see that this means a well insulated wall may really be much more expensive because of the rapid erosion of the inside walls, than the less efficient wall which will stand up a very long time because some of the heat is radiated from it.

Our problem, therefore, is to insulate our wall to just the proper degree in just the proper place or else to provide some means of ventilating the wall or better yet to cool the wall by means of water or steam in such manner that the heat transferred to the cooling fluid may later be reclaimed for useful work.

When the use of insulating brick is being considered it is well to remember that such brick may usually be used with entire safety in the construction of all sections of the furnace other than the high heat zone of the combustion chamber. Where the gas temperatures is 2400 deg. F. or less the insulation can be built in the wall as close as 9 in. from the inside

(Concluded on Page 260)

# Trade Notes and Publications

## Power Plant Lubrication

To the executive or engineer seeking a thorough discussion of any lubricating problem, we strongly recommend this exhaustive treatise recently distributed by the Tide Water Oil Sales Corporation of New York City.

Beautifully bound in artistic covers, its 60-pages of applied information form an asset to any technical library or file.

No feature of the general problem has been omitted. As its first sub-head implies, it "covers the latest developments in the lubrication of Power Plant Machinery." Profuse illustrations in colors, emphasizing the points of contacts needing oil, make clear at a glance the magnitude of this important problem.

Copies are available free to interested parties upon request.

## Koppers Company Buys Meadows Tract

The Koppers Company, of Pittsburgh, Pa., designers and builders of by-product coke and gas oven plants, has purchased a tract of about thirty-five acres south of the aviation field along the Connecticut river, and another piece of about five acres just north of the aviation field, and also fronting the river. It is believed the company has purchased the land as a factory site, although the company is not expected to begin operations in this city within the year.

## Electric Heat

Controlled Heat is the frontispage caption of Vol. 2, No. 1 issue of this interesting little magazine published by the Westinghouse Electric & Mfg. Company. Mr. A. M. Staehle, managing editor, formerly editor Blast Furnace & Steel Plant is responsible for this addition to scientific trade literature.

Within this month's covers will be found Heat Treating Electrically by J. F. Kelly; Eliminating "Cloudy Finish", by F. Arnold; Better Eggs—Electrically; Long Distance Heating, by L. V. Curran; Prolonging the Life of Transformer Cells, by Edmund J. Henke.

## A New Publication on Brass Melting

An interesting new publication on brass melting has just been issued by the Detroit Electric Furnace Company. This little booklet tells, first, that the electric furnace is a factor of ever increasing value in brass melting. It next enumerates the economies effected by the electric furnace and then shows how complete control of analysis, color, texture and homogeneity of the alloy is secured through the electric furnace. There is a section on test data showing how foundry costs are reduced an average of $10.00 a ton through the use of the electric furnace.

The bulletin is known as No. 41. Copies may be had by addressing the Detroit Electric Furnace Company, 2335 First National Bank Building, Detroit, Michigan.

## Time Elements in Iron Ore Reduction

(Continued from page 250.)

room to remove 0.097 lb. of $O_2$ from the ore per minute, the experimental furnace "as a whole" has about 10 times the volume actually required for the reduction process. The volume of efficiency of reduction for the furnace is therefore about 10 per cent if such a coined term as this is permissible.

It has already been pointed out that 82 cu. ft. of the volume of the furnace is chemically inactive. Nevertheless, it is not possible to assume that this lower portion of the furnace is metallurgically useless. Nor is it at all essential to make a decision on this point in the case of the Bureau's furnace. This experimental furnace, although possibly larger than necessary for the particular burden and operating conditions discussed in this series of papers, is about as small a unit as is practicable for experimental purposes.

TABLE VII. - Gas Composition in Plane 4.

(18 ft. 1 in. above tuyeres, 8 ft. 4 in. below stock line.)

| Sample No. | Distance from wall in inches. | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ | Per cent $CO_2/CO$ |
|---|---|---|---|---|---|---|
| 1 | 4 | 0.5 | 34.4 | 0.9 | 64.2 | 0.01 |
| 2 | 6 | 0.6 | 34.6 | 1.2 | 63.6 | 0.02 |
| 3 | 10 | 1.4 | 34.5 | 1.2 | 62.9 | 0.04 |
| 4 | 15 | 2.0 | 30.9 | 1.9 | 65.2 | 0.06 |
| 5 | 20 | 1.2 | 31.1 | 1.9 | 66.8 | 0.04 |
| 6 | 24 | 0.4 | 34.8 | 1.0 | 63.8 | 0.01 |
| 7 | 29 | 0.3 | 33.4 | 1.1 | 65.2 | 0.01 |
| 8 | 38 | 0.3 | 32.9 | 1.2 | 65.6 | 0.01 |

TABLE VIII. - Gas Composition in Plane 5.

(5 ft. 8 in. above tuyeres, 10 ft. 9 in. below stock line.)

| Sample No. | Distance from wall in Inches. | Per cent $CO_2$ | Per cent CO | Per cent $H_2$ | Per cent $N_2$ | Per cent $CO_2/CO$ |
|---|---|---|---|---|---|---|
| 1 | 6 | 0.4 | 32.8 | 0.2 | 66.6 | 0.01 |
| 2 | 16 | 0.4 | 32.0 | 1.3 | 65.3 | 0.01 |
| 3 | 22 | 0.0 | 32.6 | 0.7 | 66.7 | ---- |
| 4 | 37 | 0.2 | 32.6 | 1.1 | 66.1 | 0.01 |
| 5 | 47 | 0.3 | 30.4 | 1.1 | 68.2 | 0.01 |
| Mean |  | 0.3 | 32.1 | 1.0 | 66.5 |  |

The question whether 20,000 cubic feet of furnace volume is essential and economically desirable for a 500-ton blast furnace is important enough to warrant considerable study. In fact, as a result of the experiments described in this paper, the Bureau of Mines has undertaken to repeat the sample-tube experiments on a number of full-size furnaces. This work has been in progress for about a year, and some valuable data of practical value have been obtained. Any deductions in regard to the furnace size necessary in industrial practice must wait until further progress in this plant investigation has been made.

# WITH THE EQUIPMENT MANUFACTURERS

## Distinctive Electric Furnace Unit Installed

A little over a year ago the Gleason Works at Rochester, N. Y., were confronted with the problem of heat treatment of high speed tools for automatic gear cutting machines, the chief product of this company. In the finishing heat treatment operation these tools required a temperature approximating 2350 deg. F. before quenching. The method of treatment at that time was in an oil furnace, but the results secured were not entirely satisfactory because of the ununiform heating conditions resulting in ununiformity in the finished product, especially as it pertained to hardness. Towards the solution of the problem the Gleason Works have just placed in operation an electric furnace unit of distinctive type designed and manufactured by F. J. Ryan & Company of Philadelphia.

Previous electric furnace developments have not proved satisfactory on this work because of the impossibility of providing resistance capable of withstanding temperatures higher than 2,000 deg. F. During the war the German chemists developed a type of quartz carbon resistors for which it was claimed working temperatures up to 2,400 deg., and with a hope of them solving the temperature problem a few were imported by the Ryan Company. They were found, however, too fragile for general commercial usages at the temperature desired. The Ryan Company then commenced experimentation on the use of solid graphite resistors. In its early tests the electrode oxidized very quickly; in fact, burned out before the desired temperature had been reached.

In the first experiment with these solid graphite resistors power in the amount of 27 kw. was applied, but as stated this did not secure the results. Working on the theory that some method would have to be devised to counteract the effect of oxidation on the heated electrode, that is a method whereby the heat of the electrodes could be increased instantaneously to a great many degrees higher than the possible saturation affinity of the air, the Ryan Company designed a special low voltage transformer, which was built by the Wagner Electric Manufacturing Company of St. Louis. These results were satisfactory for commercial usages. Temperatures up to the working conditions of the furnace were reached easily and it was found that after this temperature was reached the power input of this transformer could be reduced to the original calculation of necessary input. Therefore, the high power input is only used for bringing up the temperature and to overcome oxidizing conditions. After operation of the furnace for some period it is found that tools of exceptional quality are being secured.

One of the distinct advantages covered by this furnace design is the fact that the tools are conveyed automatically through the furnace and are then extruded directly into the quenching bath. The heat of the tools entering the quenching bath causes fumes to be given off which prove a direct benefit to both the electrode and to the tools. Towards the extension of the life of these graphite resistors, further experiments were carried out and it was found by the injection of a small amount of gas into the high heating chamber that from 30 to 40 hours of continuous service can be obtained. Experiments are now being carried out towards the coating of the electrodes with the viewpoint of extending even this present life.

The complete description of the furnace is briefly a unit made up of two chambers, one the mean heating chamber in which metallic resistors are used, and the final heating chamber in which the graphite resistor is used. The two chambers are separated by a wall. Both chambers are automatically controlled with L. & N. temperature control devices with power input and switches designed by the Ryan Company.

## New Induction Motors on Market

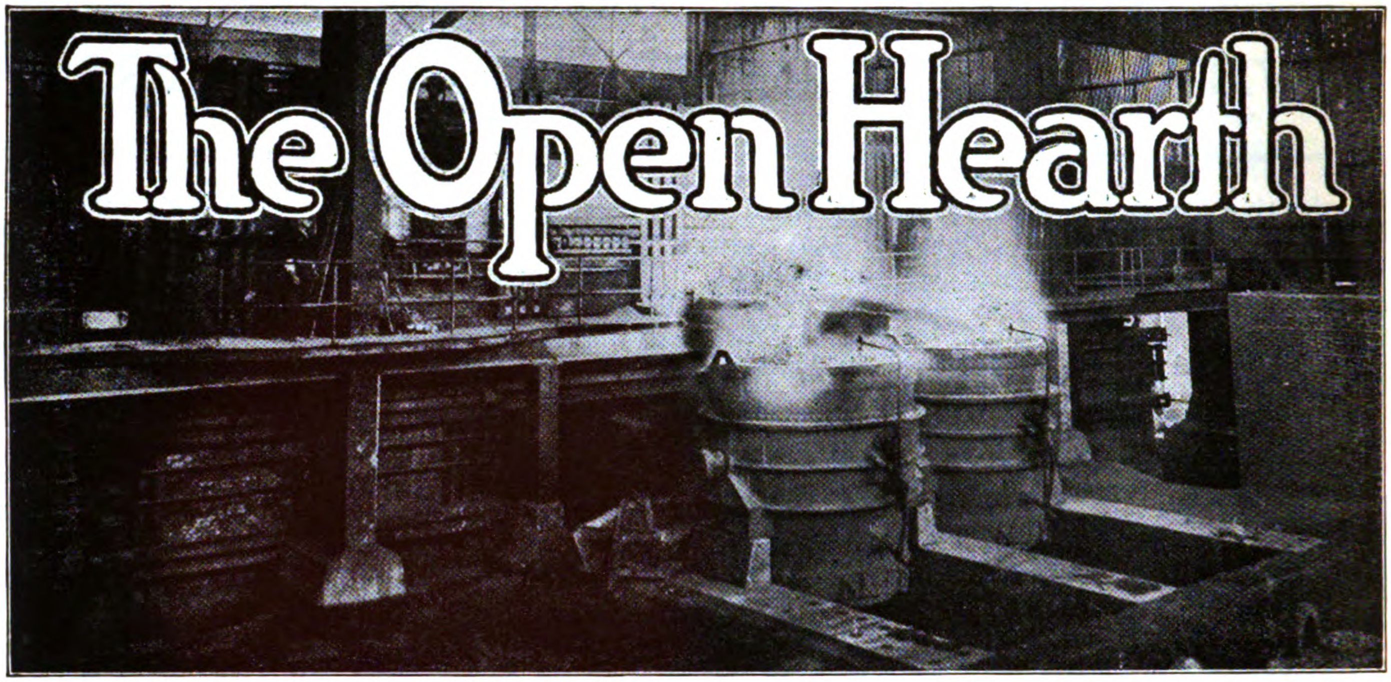
Two new types of induction motor are now being marketed by the General Electric Company. The SCR single-phase motors are designed for constant speed at 60, 50 or 40 cycles, in sizes from ½ to 10 hp., and are interchangeable for 110 or 220-volt circuits. The KT-900 type is a riveted frame, polyphase induction motor, of three and two-phase, squirrel cage, 60-cycle design, and is being sold in sizes ranging from ½ to 15 hp.

The new single-phase motor, operating on the squirrel cage induction principle, entirely eliminates the short circuiting switches heretofore considered essential and permits very simple construction. It combines high starting torque with low current demand and has operating characteristics similar to those of the induction motor. Both the maximum and accelerating torques are approximately 200 per cent full load torque without any low points during acceleration. The no load and full load speeds are respectively about 3 per cent above and below synchronous speed, giving very close regulation for a motor of this type.

The stator winding consists of simple concentric polar windings arranged for double voltage connections. The rotor contains the cast squirrel cage winding and a repulsion wire winding of the multiple type with equalized commutator connections to insure uniform distribution of armature currents.

The polyphase motor is a 40-deg. continuous duty, riveted frame, machine. The electrical improvements embodied in this new line comprise reduced heating, higher efficiency and higher power factor at full and fractional loads, and increased starting torque, the maximum torque ranging from 275 to 300 per cent of full load synchronous torque for different sizes. The accelerating torque curves are free from dips common to those of preceding types.

The principal mechanical improvements include from 50 per cent to 100 per cent increase in oil reservoir capacity, a new method of directing the ventilating air to prevent dirt from settling on the windings, and a "cast" rotor of one-piece construction having no joints nor high resistance spots.



# The Open Hearth

Judge E. H. Gary, chairman of the United States Steel Corporation, returned from Rio de Janerio to the United States about April 15.

Wade H. Oldham, recently appointed general superintendent of the Fairfield steel works of the Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., formerly was superintendent of the Ensley blast furnaces for that company.

George H. Millar, former superintendent of the Fairfield plant now is assistant to Mr. Oldham while R. H. Ledbetter has succeeded Mr. Oldham at Ensley. Mr. Ledbetter formerly was connected with the Bessemer plant. The changes were effective as of April 1.

Eugene Rich, engineer, formerly with a construction company at Indianapolis, Ind., is now connected with the Bourne-Fuller Co., and is working out of the company's Cincinnati office on reinforced concrete projects.

E. R. Perkins of Tarentum, Pa., has been appointed general manager of the Allegheny Steel Co., Brackenridge, Pa., succeeding V. B. Browne who has been appointed assistant to the president, Harry E. Sheldon.

C. A. Wills, general foreman of the Wm. B. Pollock Co., Youngstown, blast furnace builder, has been named general superintendent to fill the vacancy caused by the death of John Kirby. Mr. Wills has been in the employ of the Pollock company for many years.

James Bowron, chairman Gulf States Steel Company, is making a tour of South American countries. He is expected to return to Birmingham, Ala., in May.

Mr. G. H. Richards, Weirton Steel Company, Weirton, W. Va., has been transferred to the Steubenville plant of the same company. Mr. J. R. Black goes back to Weirton in Mr. Richards' position.

J. W. Bell, who was construction engineer for Perin & Marshall, New York, during the erection of the new mill of Tinplate Company of India, has entered into partnership with W. J. Douglas under the name of Douglas & Bell, at 200 Abbey House, Victoria street, London, S. W. I. A general iron and steel engineering business will be conducted.

W. Y. Stroh, president, Stroh Steel-Hardening Process Company, Pittsburgh, who is visiting Great Britain on business, has established temporary headquarters at Ormonde House, St. James street, London, S. W. I. Mr. Stroh is investigating the possibilities of the steel casting industry in Great Britain, where he expects to remain two or three months.

T. R. Harrington, recently placed in charge of the research department of the Brown Instrument Company, Philadelphia, manufacturer of pyrometers, thermometers and other indicating and recording instruments, formerly was associated with the pyrometry department of the bureau of standards, Washington, and more recently was connected with the Champion Porcelain Company, Detroit.

W. D. Moore, a prominent figure in cast iron pipe manufacturing circles, has been made president of the American Cast Iron Pipe Company, Birmingham, Ala., succeeding John J. Eagan, Atlanta, Ga., resigned. Mr. Moore has been with the Birmingham plant for 15 years, having gone there from Galion, Ohio, in 1907. For a brief time he was connected with the Tennessee Coal, Iron & Railroad Co. at Ensley. He went with the Cast Iron Pipe company in 1908 and worked his way through every department of the company, becoming vice president and works manager in 1922. He is the inventor of a centrifugal method of making pipe. John J. Eagan has been connected with the American Cast Iron Pipe Co. since its organization. For several months past he has been seriously ill, and while his condition is improving, his forced absence from business affairs, prompted him to resign. He will continue his connection with the company as advisory director. Mr. Eagan installed the plan of industrial government at Acipco, which is based on practical application of the golden rule to industry. Other officers of the company are Paul A. Ivy, vice president and general sales manager; C. D. Barr, vice president and director of purchases; C. O. Hodges, assistant treasurer.

# NEWS OF THE PLANTS

The Alan Wood Iron & Steel Company, Widener Building, Philadelphia, Pa., has plans under way for extensions and improvements in its plant at Conshohocken, Pa., devoted to the production of steel billets, sheets, and kindred products. The work will consist of new one story structures to be equipped as finishing mills, and the enlargement of existing buildings now being used for similar purpose, with the installation of considerable additional equipment. The company has disposed of a bond issue of $3,500,000, a portion of the fund to be used for the expansion, and the remainder to be employed for financing. Richard G. Wood is president.

The St. Louis Coke & Iron Company, St. Louis, Mo., has commenced operations at the blast furnace of the Mississippi Valley Iron Company, South Broadway, St. Louis, recently leased for a long period. The plant has been inactive for a number of years past, and the lessee proposes to develop maximum capacity at the 400-ton rating at an early date. The unit is in good condition, having lately been relined and improved. It will be used for the production of pig iron. The St. Louis company has arranged to make immediate improvements at its blast furnace at Granite City, Ill., and the unit will be relined and otherwise rebuilt. It has been in blast for close to two years past. While the furnace is down, the company will concentrate operations at the St. Louis stack.

The Wheeling Steel Corporation, Wheeling, W. Va., is pushing final construction at its Steubenville, Ohio, mills, and expects to have the work completed at an early date, when the plant will be developed to maximum capacity. The remaining expansion is centered largely in the open-hearth department, covering changes in present equipment, and the installation of additional apparatus. The new blooming mill has been completed, as has the new sheet bar mill, and both of these units are now in active service. The expansion program has been in progress for some time past, and represents a large investment.

The Illinois Steel Company, 208 South La Salle Street, Chicago, Ill., is said to be arranging for the immediate rebuilding of the portion of its works at Gary, Ind., destroyed by fire recently. The loss was centered largely in the naphtha department, and is estimated at $140,000, including buildings and equipment. The reconstruction is estimated to cost approximately the amount of the fire loss.

The Carpenter Steel Company, Reading, Pa., has plans nearing completion for the erection of a new addition to its plant on the River Road, to be one-story, 55 x 100 feet, equipped for general production, estimated to cost approximately $210,000, with machinery. Work will be commenced at an early date. F. H. Muhlenberg, Ganster Building, Reading, is engineer.

The Ford Motor Company, Highland Park, Detroit, Mich., is perfecting plans for the erection of a large steel mill at its River Rouge works. The initial unit will be 500 x 1700 feet, forming one of the largest structures of its kind ever built. It will be supplemented with other buildings at a later date. The plan will cost more than $1,000,000, with machinery. Albert Kahn, Marquette Building, Detroit, is architect.

The Superior Steel Products Company, Beaver Falls, Pa., recently formed, is perfecting plans for the erection of a new plant on site selected at Monaca, Pa., for the manufacture of steel bars, steel plates and kindred products. The initial unit will be 60 x 300 feet, and is estimated to cost close to $90,000, with equipment. Other structures will be erected at an early date. The officials of the new company formerly were connected with the Moltrup Steel Products Company, these being M. P. Simpson, who will act as president; Williams Elmes, vice president; and Frank H. Guppy, secretary. Homer H. Swaney, a member of the firm of Martin & Swaney, attorneys, Beaver Falls, has been elected treasurer of the new organization.

The Fairfax Iron & Steel Company, Kansas City, Kan., care of Horner & Wyatt, 306 McMillen Building, Kansas City, engineers, has plans nearing completion for the erection of a new steel plant on tract of property selected in the Fairfax Drainage District. The initial unit will be one-story, brick and steel, 160 x 700 feet, and is estimated to cost close to $200,000, including equipment, for which it is expected to place orders at an early date. Extensive production is planned.

The Colorado Fuel & Iron Company, Pueblo, Colo., is perfecting plans for a number of extensions and improvements in its local steel mills to provide for considerable increase in output and better efficiency in operation. The program will require close to 24 months for completion, with initial work to include enlargements in the power department, with high pressure boilers and superheaters, electric generators and auxiliary apparatus. Electric drives will be arranged in different rolling mills to replace present steam operation. New electric precipitators will be installed for cleaning blast gas. With other work to be carried out later, the project will involve close to $2,500,000. The first contracts will be let during the spring.

The Dominion Alloy Steel Corporation, Sarnia, Ont., operating with a capital of $15,000,000, has commenced the erection of the initial units of its proposed local mills, for which plans have been in preparation for a number of months past. The company has a tract of about 250 acres of property, fronting on the St. Claire River, in the vicinity of the works of the Imperial Oil Company. The buildings to be erected at the present time include the open-hearth department, for the production of bars and shapes, estimated to cost in excess of $1,200,000, with equipment. Electric furnaces will be installed. The present unit will have a rated capacity of about 45,000 tons per year, and is expected to be ready for service in the fall. At that time, work will begin on the other plant units, which will be rushed to completion. William B. Boyd, Toronto, is president of the company; R. V. LeSueur, Sarnia, is vice-president; and N. L. LeSueur, Sarnia, secretary. C. Harold Wills, Marysville, Mich., head of the Wills-Sainte Clair Company, manufacturer of automobiles, is prominent in the new organization.

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## Metalloids in Basic Pig Iron in Basic Openhearth Practice

(Continued from Page 224)

It is to be emphasized that a residual manganese in excess of 0.25 per cent not only reduces the openhearth cost per ton of ingots by decreasing the quantity of expensive ferromanganese that must be added to the heat to attain a given manganese percentage, but because of the protection it gives against overoxidation in the furnace, the quality of the steel is improved. This higher quality steel increases the percentage of merchantable product at the mills by from 1 to 3 per cent, depending on the amount that the residual manganese exceeds 0.25 per cent; and while such a saving cannot be properly shown on the openhearth cost sheet, it increases the net profits of the works as a unit. The protection afforded against overoxidation by a proper percentage of residual manganese may be accounted for by the following reasoning: The oxygen of the ore first attacks the manganese, phosphorus, and silicon and at the higher temperatures the carbon oxidation takes precedence. As the carbon content of the bath decreases, iron oxidation sets it; and at the lower carbon percentages the protective power of carbon oxidation is very low. It seems apparent, therefore, that in the lower carbon ranges the 0.25 to 0.40 per cent manganese, which at all temperatures is more easily oxidized than iron, can act only as a preventative of overoxidation of the steel.

TABLE XV — EFFECT OF RESIDUAL MANGANESE ON MANGANESE ADDED IN LADLE

| | Residual Manganese, Per Cent. | Tons Ingot | Weight Manganese in Bath, Pounds | Weight Manganese, Required Pounds | Theoretical Added Manganese, Pounds | Actual Pounds Manganese in Ladle | | Pounds 80 Per Cent. FeMn |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Ton | Heat | |
| Scrap | 0.24 | 40.90 | 232 | 386 | 154 | 7.8 | 319 | 399 |
| Standard iron, high $SiO_2$ | 0.20 | 42.36 | 198 | 396 | 198 | 10.0 | 424 | 530 |
| Standard iron, low $SiO_2$ | 0.23 | 42.57 | 230 | 398 | 168 | 8.5 | 362 | 453 |
| High-manganese iron, high $SiO_2$ | 0.34 | 42.44 | 338 | 397 | 59 | 2.9 | 123 | 154 |
| High-manganese iron, low $SiO_2$ | 0.40 | 42.70 | 399 | 399 | 0 | 1.0 | 43 | 54 |
| Excess limestone | 0.16 | 41.97 | 157 | 393 | 236 | 12.0 | 504 | 630 |
| High silicon iron | 0.12 | 42.04 | 118 | 394 | 276 | 14.0 | 589 | 736 |
| High phosphorus iron | 0.16 | 42.53 | 159 | 398 | 239 | 12.0 | 510 | 638 |

The weight of iron oxidized and carried away in the waste gases was taken in all ore heats to be 100 lb. per heat and the quantity of manganese lost in a similar way to be about 200 lb. per heat, in the cases of the high-manganese iron, and about 100 lb. per heat in the others. In the case of the scrap heat, these losses were taken at 150 lb. per heat for both iron and manganese.

As a matter of precaution, the percentage of phosphorus remaining in the steel, in the case of the high-phosphorus iron heat, was placed at 0.03 per cent instead of 0.01 per cent. The sulphur content of all the slags was put at 0.25 per cent, which is both conservative and common in practice. All the calcium, magnesium, and aluminum oxides carried in with the charge appear in the slag.

Sulphur elimination in the open-hearth furnace is, at best, an uncertain and costly procedure. In the earlier days of the industry, when the use of natural gas was general, high-grade producer coal was available for those plants outside the gas belt and scrap heats more generally charged; there was then but little difficulty in holding the sulphur content of the steel at 0.04 per cent and below, provided that the sulphur in the iron corresponded approximately to this percentage. With the advent of the higher percentage iron charges and lower grade fuel, the difficulty of producing low-sulphur steel has been tremendously increased. While probably sulphur above 0.04 per cent is not, in many instances, prejudicial to the physical quality of the steel, the general trend of specifications is in the direction of lower, rather than higher, sulphur content. Regardless of the merits of either side of this controversy, one must meet specifications as they exist. Under such conditions and with low-manganese iron (1.00-1.25 per cent) the percentage of sulphur in the pig iron must be practically as low as that desired in the steel.

As coke also has followed the downward trend in quality, it has become more difficult for the blast furnaces to produce consistently iron with the sulphur content desired by the open hearth, and this difficulty is increased by the necessity of maintaining a silicon content in the iron not appreciably above 1 per cent.

Under a condition of approximately 1 per cent manganese and 0.05 per cent sulphur in the iron and a sulphur content of 0.04 per cent being required in the steel, or with a like manganese content and 0.04 per cent sulphur in the iron and 0.035 per cent sulphur or under being required in the steel, the open hearth is forced to adopt one of two methods of sulphur elimination, both of which are uncertain and costly. The usual method is to charge additional limestone, probably because the expense incurred is not so obvious as when ferromanganese is used. The cost sheet shows an increased cost of $0.87 per ton in the case of the heat heavily overchanged with limestone compared to the so-called standard heat charged with a normal amount, and the same relative increase of cost would have followed any proportional increase or decrease in the excess charged. Assuming that to accomplish an equal reduction in sulphur it has been necessary to use 10 lb. of pure manganese per ton of ingots, the cost of such sulphur removal added to the cost of ingots in the case of the standard iron heat would bring the total cost to **$31.43. This figure is $0.14** lower than the cost of the limestone heat, although it has not been credited with the reduced ladle addition of manganese, and the improvement in the quality of the steel.

It will be observed on the chemical balance sheet that all irons are assumed to carry 0.014 per cent sulphur, but that the steel produced with the 2-per cent manganese iron contains 0.035 per cent sulphur, which is more than would result in practice under the conditions of charge and fuel assumed. Whether the open hearth is required to produce 0.035 per cent and under sulphur in the steel from 0.04-per cent sulphur iron, or 0.04 per cent sulphur in the steel from 0.05-per cent sulphur iron, the cost of accomplishing this is, in all cases, less with 3-per cent manganese than with 1-per cent manganese iron. Furthermore, because of the sulphur eliminated from the high-manganese iron in the transfer ladle between the blast furnaces and the open hearth and in the open-hearth mixer, 0.04-per cent sulphur steel can be regularly and economically produced from such iron, even though its sulphur content rises to 0.07 per cent.

With the thought of presenting greatly contrasting costs and thus emphasizing the loss sustained through the charging of unnecessarily high-silicon irons, the silicon content of all the irons has been assumed at 0.75 per cent; such an amount is not only practical but desirable in the case of the 2-per cent manganese iron. On the other hand, 0.75 per cent silicon iron with 1 per cent manganese would, in actual practice, cost more to produce than an iron containing 0.75 per cent silicon and 2 per cent manganese; and, unless made very hot physically at the expense of increased coke charges, the works as a unit would suffer a loss because of delayed operations and excessive scrap, from badly skulled ladles, mixers, and runners.

In the case of the high-silicon iron heat, the assumption of the use of 1.75-per cent silicon iron may be radical, but the use of such iron is not as unusual as may be supposed; and while the physical results of its use in the open hearth may be readily perceived, its effect on costs is not usually considered.

While the costs of the low-silica ore heats do not strictly come within the province of a paper dealing with metalloids, they are shown to emphasize the harmful effect of such unnecessary impurities upon practice and costs. In the case shown, the difference in cost between the so-called standard iron heat, and the low-silica ore heat was $0.43 per ton of ingots in favor of the latter. It is apparent from this that if low-silica ore can be procured at the same cost as the high-silica ore, that the use of the last named is nothing short of criminal waste.

In closing, I wish to acknowledge the help given in the preparation of this paper by my assistant Roger B. McMullen, Jr.

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The Galt Machine & Screw Co., Ltd., have been recapitalized under Dominion Charter for $500,000, and have taken over and will continue to operate on a much larger scale the business formerly carried on by the Galt Machine Screw Co., Ltd. This company has been noted as manufacturers of high-grade automatic screw machine products and specialties, and will continue to manufacture only the highest-grade products. Considerable new equipment will be added from time to time, and the company will be in position to give excellent service to American manufacturers who desire to have high-grade specialties and small machines manufactured and distributed in Canada.

The officers of the new company are: R. W. Roelofson, president C. E. A. Dowler, vice president, and C. K. Jansen, secretary-treasurer.

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The Gellert-Cottrell electrical cleaning plant which the Colorado Fuel and Iron Company will install to clean the fume and dust from its blast furnace gases will be the largest plant of its kind that has yet been installed for this work either in America or Europe.

Long period testing on a standard size unit was conducted by the Colorado Company at its own plant before it was decided to install the cleaners. The latest tests show that the gas could be cleaned to such an extent that only 0.11 grains of dust per cubic foot were left in the outgoing gas.

The demonstration plant attracted great interest in the blast furnace industry and was visited by many eastern engineers in the past four months.

Specially designed automatic mechanisms will make this one of the most up to date dust precipitation plants that has ever been built.

The Gellert Engineering Company, which developed the electrical precipitation process for the blast furnace gas application, and which has built the other electrical blast furnace gas cleaning plants in this country, will design the Colorado gas cleaning plant.

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## Patent Office Needs Men

There are 200,000 applications for patents on inventions now pending in the United States Patent Office, according to a statement today of the United States Civil Service Commission. To speed up action, Congress has authorized an appropriation which will permit the addition of 100 to the present examining force of 500.

The Civil Service Commission will hold examinations on May 7 and later dates for positions of assistant examiner in the Patent Office. The entrance salary is $1,860 a year, and increases are provided up to $5,000 a year.

Full information concerning the examination may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the civil service board at the post office or custom house in any city.

The commission states that of approximately 80,000 applications for patents made annually, fully two-thirds of them relate to some phase of the automobile industry. The present system in the Patent Office of examination before issue was authorized by an act of Congress of 1836. The system has been copied by practically all large countries.

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The Chapman-Stein Furnace Company, of Mt. Vernon, Ohio, announces the addition of William C. Buell, Jr., to their engineering staff. Mr. Buell has had a broad training along combustion lines and a very valuable practical experience in furnace designing and construction. From 1906 to 1914 he served as engineer for the Westmacott Furnace Company when they were redesigning their heat-treating, melting and annealing furnaces.

## Economical Operation and Maintenance of Boiler Furnaces

(Continued from Page 251)

face of the wall without detriment to the refractory brick work, provided calcined insulation of considerable high heat resisting quality is used. A survey of the temperature drop through any boiler setting will show that the high heat zone of the combustion chamber is of limited area.

In addition to the danger of failure of the brick work, there has been another reason for not placing insulating brick in the high heat zones in the wall. This has been due to the fact that the insulating brick heretofore available have shown considerable shrinkage under high temperature conditions. There are, however, now available insulating brick that have shown by test no shrinkage under pressure of 40 lbs. per square inch at 1900 deg. F. and but slight shrinkage at 2000 deg. F.

Fig. 1 plotted from the Bureau of Standards tests shows the relative conductivity of fire brick, red brick and insulating brick at various temperatures.

Fig. 2 is a graphic presentation of comparative losses through un-insulated and insulated furnace walls of standard thickness and with different methods of construction.

By referring to the side wall sections, B and C and D the savings resulting from the use of insulating brick are shown to be very marked.

Among the advantages of insulated walls are that overloads may be more uniformly maintained, with better efficiency. Moreover in all types of boilers which are supported by steel structure and are not dependent on the walls for support, thinner walls can be used, the cost of construction reduced and space saved, when insulating brick are built in as part of the wall structure.

### Keeping Down Maintenance.

Frequent reconstruction of furnace linings and unnecessary fuel waste may be due to any or all of the following:

1. Use of inferior refractories.
2. Thick joints between bricks.
3. Cracks in furnace walls.
4. Lack of insulation.
5. Failure to make minor repairs.

The life of most furnace linings can be lengthened and their general efficiency increased by:

1. Proper selection of refractories.
2. Bonding with thin cemented joints or
3. Monolithic construction of walls and arches.
4. Insulation properly installed as an integral part of the structure.
5. Frequent minor repairs.

### The Brick and the Joint.

High grade fire brick laid up with thin cemented joints will give long life to any furnace lining. A refractory cement which sets at normal room temperatures will bond the brick, which are dipped when laying into a thick batter of cement, then tamped or rubbed into place with a thin "push" point.

The action of heat merely serves to strengthen the bond by fusing brick and cement together in a solid structure. The bond extends through the entire thickness of the wall.

### Monolithic Construction.

This method of constructing furnace linings, has been gaining in favor and will no doubt be given increasing consideration by engineers.

Two means of monolithic construction are available;

1. The use of prepared mixture either wet or dry.
2. The reclaiming of old furnace linings by crushing the old fire brick and adding the proper percentage of plastic high temperature cement.

It has been found that monolithic walls for boiler furnaces effect savings both in construction and operation.

The advantages of this method include:

1. Reclaiming old firebrick.
2. Low cost of construction.
3. Longer service from lining.
4. Reduced infiltration.
5. Reduced heat losses.
6. Lower fuel consumption.
7. Operation at higher capacities.

In concluding our discussion of this subject next month we will deal with methods of furnace construction, bridge walls, first suspended arches and baffles.

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## Synopsis of Papers Given Before American Electro-Chemical Society

"Organic Electrochemistry," Dr. C. J. Thatcher, chairman.

"The Electrolytic Preparation of Salicylic Aldehyde from Salicylic Acid," Kendall S. Tesh and Alex. Lowy.

"The Electrolytic Reduction of $\beta$-Anthraquinone Sulfonic Acid," Alfred R. Ebberts and Alex. Lowy.

"The Electrolytic Preparation of Metanilic Acid and Its Possibilities," Arthur K. Doolittle.

"The Electrolytic Oxidation of p-Nitrotoluene and p-Chlorotoluene to their Respective Acids," Raymond F. Dunbrook and Alex. Lowy.

"Electrochemical Oxidation of Aromatic Hydrocarbons," Fr. Fichter.

"The Function of Peroxides and Peracids in the Electrochemical Oxidation of Organic Compounds," Fr. Fichter.

"Electrolytic Production of Cobalt and Nickel Triacetates from the Diacetates; the Electrolytic Production of Nickel Triacetates," C. Schall and H. Markgraf.

Symposium on "Recent Progress in Electrodeposition," Mr. S. Skowronski, chairman.

"Recent Progress in Electroplating and Electroforming," Wm. Blum.

"Nickel Anodes," C. T. Thomas and W. Blum.

"Conductivity of Nickel Depositing Solutions," L. D. Hammond.

"The Relation Between Polarization and Structure in the Electrodeposition of Metals," V. Kohlschutter.

"Acidity of Cobalt and Nickel Plating Baths. The Use of the Oxygen Electrode," G. H. Montillon and N. S. Cassel.

# Some Pointers on By-Product Coke Oven Operations

## Electric Furnace Refractories

The original edition of "Refractories for Electric Furnaces" was a report of the proceedings of the Electric Furnace Association and included the papers presented at one of its meetings, together with a stenographic record of the discussion which followed. The booklet proved to be a popular one and when the supply of copies neared exhaustion the board of directors of the American Electrochemical Society, which took over all the printed copies when the Electric Furnace Association became merged in the Electrochemic Division of the Society, decided to bring out a new edition. This differs from the original because it was thought desirable, while preserving most of the papers which were printed in the first edition, to make a number of additions with the object of bringing the book up to date. There have been a few minor changes in the original papers, while one of these, that by Hartman on carborundum refractories, has been completely rewritten. New papers specially written for this edition are: the one by L. C. Hewitt, the one by the Norton Company and the one by Clyde E. Williams of the Bureau of Mines.

This edition contains the following original papers, complete as chapters:

| | |
|---|---|
| "Refractories for Electric Furnaces," by Raymond M. Howe | 5 |
| "Refractories for Electric Furnaces," by Clyde E. Williams | 18 |
| "Some Properties of Refractories," by R. T. Stull | 30 |
| "Refractories for Electric Furnaces," by Homer F. Staley | 41 |
| "Electric Furnace Refractories," by C. W. Berry | 50 |
| "Aluminous Refractories for Electric Furnaces," by L. C. Hewitt | 53 |
| "Electric Furnace Refractories," by A. F. Greaves-Walker | 60 |
| "Carborundum Refractories in Electric Furnaces," by M. L. Hartmann | 69 |
| "Refractories for Electric Furnaces," by Refractories Dept., Norton Company, Worcester, Mass. | 81 |
| Discussion | 88 |
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## Committee Appointed to Make Cement Survey

The secretary of commerce has appointed an advisory commitee to make, under the general direction of the Department of Commerce, a comprehensive survey of the properties and uses of cement and concrete. The committee will co-operate with the Bureau of Standards and officials of the department.

The committee consists of: John Lyle Harrington, chairman, engineer, Kansas City, Mo.; C. E. Boynton, cement manufacturer, New York, N. Y.; N. Max Dunning, architect, Chicago, Ill.; H. C. Turner, contractor, New York, N. Y.; Chas. M. Upham, highway engineer, Raleigh, N. C.

The cement industry has grown so rapidly and has achieved such great importance in the United States that the use of cement in the construction of roads, bridges and buildings has become so great and so diversified that the intelligent and appropriate use of this material becomes a matter of great economic interest to the public.

Research work is now being carried on by the Bureau of Standards and by various organizations in the properties, characteristics and proper use of cement; in the improvement of methods, equipment and appliances tending toward improved efficiency and economy; the seasonal use of cement, especially in winter weather, important in its relation to continuity of employment of labor and the elimination of "peaks" and "depressions" and the spread of manufacture and distribution more evenly.

It is proposed through the survey to co-relate for the benefit of the industry and the public the results of such scientific and technical activities and to center in and under the direction of the Department of Commerce a thorough and disinterested study of the entire subject. It is believed that such concentration of effort as the committee proposes to bring about will produce material results in the elimination of wasteful duplication of effort, and effect savings to the public and result in benefit to the manufacturer.

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## $15,000,000 STEEL PLANT ASSURED LOS ANGELES

The $15,000,000 steel mill for Los Angeles Harbor is now assured.

As a site for the gigantic plant, final negotiations were completed yesterday by the Pacific Coast Steel Corporation for the purchase of a 200-acre tract in Long Beach from the Los Angeles Dock and Terminal Company, for a consideration of $2,000,000.

For the last four months the steel corporation has had an option on the property, but it was not until yesterday that the board of directors definitely decided on the site.

Announcement of the huge transaction, which marks the first step in the development of one of the biggest industries in Southern California, was made public yesterday by T. T. C. Gregory of San Francisco, attorney for the Pacific Coast Steel Corporation.

With the view of deepening and widening the harbor channel past the company's property, the corporation has deposited a bond of $250,000 with city officials of Long Beach and negotiations with government officials also are under way.

The depth of the channel is to be increased to 32 ft.

The erection of the first blast furnace in Southern California on the harbor property is part of the scheme of the development.

Parties representing the steel corporation locally in the transaction were D. M. Reynolds, vice president of the First National Bank; Attorney Walter M. Campbell and C. J. Curtis, president of the Los Angeles Dock & Terminal Company.

With the purchase of the 200-acre tract, it is the plan of the steel corporation to start immediately the development of the plant, which, when fully completed, will represent an investment of $15,000,000.

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## Koppers Coal Gas Plant at Saginaw Put Into Operation

The coal gas plant of the Consumers Power Company at Saginaw, Michigan, was put into operation last week. This plant consists of 19 small gas ovens and central plant together with the necessary by-product recovery and coal and coke handling apparatus. When the ovens are heated with producer gas the plant will have a capacity of approximately two and one-half million cubic feet of gas per day, based on 12 hours carbonizing time. This capacity can be reduced instantly to 1,725,000 cubic feet by substituting coal gas for underfiring the ovens instead of producer gas and can be further decreased by lengthening the carbonizing time. The plant can be operated at any capacity between these figures by heating any desired number of ovens with producer gas and the remainder with coal gas. The ovens and producer plant were designed and built by the Koppers Company.

Positions Wanted and Help Wanted advertising inserted under proper headings free of charge. Where replies are keyed to this office or branch offices, we request that users of this column pay postage for forwarding such replies. Classified ads can be keyed for the Pittsburgh, New York or Chicago offices.

## POSITION WANTED

MECHANICAL superintendent or assistant, 38 years of age, technical education, shop training, drafting room experience, 5 years in charge of construction, repairs and machine shop; good reason for seeking change. Box B B B, care of The Blast Furnace and Steel Plant.

CHIEF DRAFTSMAN or assistant; experienced in all branches of steel works engineering, shop, erection as well as office training; considerable experience in estimating and appropriation work. Box F J B, care of The Blast Furnace and Steel Plant.

MASTER MECHANIC with 30 years' experience on construction and operation of steel mills, blast furnaces, open hearths, Bessemer departments, by-product coke plants; constructed hydro and steam electric plants, large pumping stations, etc.; at present employed, wish to make change. Box 100, care of The Blast Furnace and Steel Plant.

CHIEF DRAUGHTSMAN—Broad and varied experience in general engineering, mechanical, structural, electrical, designing machinery, tools, power, structural steel, concrete and industrial buildings; purchase, installation and plant maintenance. Address Box A M B, care of The Blast Furnace and Steel Plant.

DESIGNING ENGINEER, experienced executive with technical training, desires position as chief engineer or master mechanic. Fifteen years' experience, including design and construction of rolling mills, furnaces, plant equipment, power plants, special machinery, etc.; four years in machine shop. Address Box F C M, care of The Blast Furnace and Steel Plant.

POSITION WANTED—A graduate mechanical engineer with 12 years' experience in rolling mills, desires a position as superintendent or assistant. Experience covers every job in a rolling mill from laborer to assistant superintendent. Also has had some office and sales training. At present employed, but desires a better outlook. Box C A S, care of The Blast Furnace and Steel Plant.

CHIEF ENGINEER or assistant to general manager. A mechanical engineer with 14 years' broad experience in steel plant construction and colliery operations is available. Age 38. Best references. Box K M, care of The Blast Furnace and Steel Plant.

POSITION by chemist, technical graduate, 15 years experience glass, animal fats, bleaching iron and steel. Six years experience as plant executive. Research work a specialty. Box L, care ofThe Blast Furnace and Steel Plant.

YOUNG rolling mill superintendent with 20 years' practical experience on iron and steel Belgian type mills, also latest continuous type steel mills, desires to make change. Can furnish records and references. Have practical knowledge of rolling and roll designing. Box F A W, care of The Blast Furnace and Steel Plant.

ENGINEER, Cornell graduate, seven years' steam and fuel engineering, three years' executive experience as master mechanic of a rolling mill, three years' sales engineering, desires change. Box S, care of The Blast Furnace and Steel Plant.

## POSITION WANTED

ENGLISHMAN, 23, of sound general and technical educations, with seven years' experience of steel making by open hearth process (acid and basic) in prominent English steel works, desires appointment where scientific and practical knowledge would be an asset. Box G B J, care of The Blast Furnace and Steel Plant.

WANTED—A position wherein the following will be of value: A fair tehnical education, a large amount of practical experience in the various mechanical arts and plant operation and maintenance with an eye on the "works operating expense" account, a fair degree of executive ability and absolute dependability. Experience has been had in production and general machine shops, rolling mills, rod and wire mills and at blast furnaces. Expert in design and construction of the Dwight and Lloyd type of sintering plant. Box C C C, care of Blast Furnace and Steel Plant.

CHEMICAL ENGINEER, 1922 graduate, leading university, desires position in a steel plant. One year's experience in the inspection department. At present employed, but available on short notice. Box J B C, care of Blast Furnace and Steel Plant.

POSITION WANTED—Electric furnace man open for position; experienced on basic Heroult electric furnaces, tool and alloy steels. Box A T, care of The Blast Furnace and Steel Plant.

WITH experienced consulting mining engineer; will go to any country. Speak French and Spanish. Box M, care of The Blast Furnace and Steel Plant.

HEATER on soaking pits or reheating furnaces; 10 years' mill experience; can give references. Box C Z, care of The Blast Furnace and Steel Plant.

SALES POSITION with manufacturers' sales agent for power plant specialties or chief draftsman or plant engineer with moderate sized manufacture Box K, care of The Blast Furnace and Steel Plant.

I DESIRE to have a position as tracer or on small drafting work with reliable concern, preferably in mechanical line. Box J, care of The Blast Furnace and Steel Plant.

YOUNG MAN, technical graduate and 7 years practical experience, would like to connect with organization needing a producer. Prefers a job which keeps him on the road the major portion of the time. He has intensive education along lines of general inspection of materials. Box I, care of The Blast Furnace and Steel Plant.

POSITION as field engineer, construction work, general survey work and right-of-way work. Box G, care of The Blast Furnace and Steel Plant.

PLANT ENGINEER or assistant to general manager. A graduate mechanical engineer, with broad training and experience is available for position requiring ability and hard work. Box F, care of The Blast Furnace and Steel Plant.

POSITION WANTED—Assistant superintendent open hearth or bloom mill. Have had quite a number of years' experience in open hearth and bloom mill practice, believe in quality steel and can furnish best of references. Box T, care of The Blast Furnace and Steel Plant.

## POSITION WANTED

POSITION WANTED by chemical engineer, degree of doctor-engineer (1916) from leading German university, 33 years old, six years' experience embracing the analysis, metallography and physical testing of steel and alloys. Nationality, Norwegian. Languages, Norwegian, Swedish, German and English. Location, anywhere. Available, any time. Can furnish best of references. Box R E D, care of The Blast Furnace and Steel Plant.

CHIEF CLERK or assistant to works manager; 32 years old, married. Ten years' experience in sheet and tin rolling mills, galvanizing, long terne and factory record and office work. Experienced from time-keeping to corporation yearly statement, including cost. Box L E T, care of The Blast Furnace and Steel Plant.

ELECTRICAL ENGINEER — Technical graduate (1912), general steel mill experience in construction and operation. Can take charge of electrical department. Desire position as assistant general superintendent or works manager, Pittsburgh district preferred. Box RM, care of The Blast Furnace and Steel Plant.

SITUATION WANTED—By-product coke-oven technical man seeks a new connection. Seven years' experience. University graduate, Ch.E. degree. Thirty-three years old; married. Box W, care of The Blast Furnace and Steel Plant.

ROLLING MILL superintendent, experienced in the heating and rolling of carbon, alloy and electric furnace steels, desires position; experienced in blooming, plate and universal mills. Highest references. Box A R T, care of The Blast Furnace and Steel Plant.

YOUNG MAN with five years' experience as machinist and three years' experience in foundry, Tech graduate, wishes position with growing firm at or near Philadelphia, Pa. Box W B, care of The Blast Furnace and Steel Plant.

POSITION WANTED by experienced roll turner and designer. Have had several years' experience in charge of roll shops, designing, etc., as well as turning rolls. Have also had experience working on the mills. Can handle position of mill superintendent, roll designer or boss roll turner. Can furnish best of references. Box P V C, care of The Blast Furnace and Steel Plant.

POSITION WANTED—Steel mill electrical engineer desires change in location. Five years' engineering and operating experience in steel mills. Technical graduate, member A. I. & S. E. E., Associate A. I. E. E.; age 32. Box A R L, care of The Blast Furnace and Steel Plant.

YOUNG MAN, technical education, desires position in Pittsburgh District as chemist on analysis of open hearth steels. The applicant is at present employed in steel work, but desires a connection offering greater possibilities. Details as to past experience and recommendations will be submitted on request. Box G P G, care of The Blast Furnace and Steel Plant.

WANTED—Position on maintenance in medium sized steel plant or factory; 12 years' drafting room experience on general mill engineering and three years' machine shop experience. Box F D J, care of Blast Furnace and Steel Plant.

TIME KEEPER—Have had several years experience. Box H, care of The Blast Furnace and Steel Plant.

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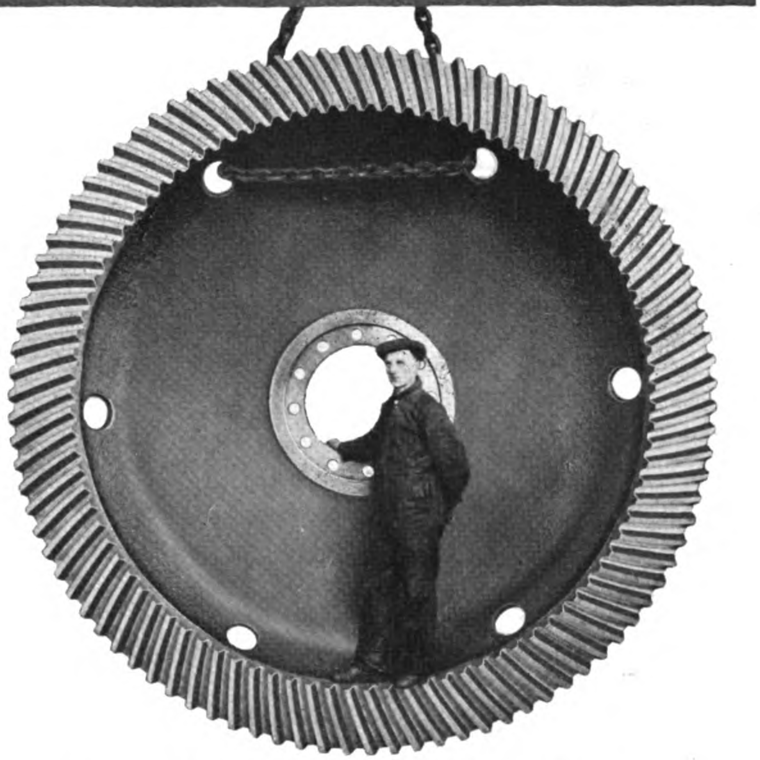

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